



The Dow Chemical Company
Midland, MI 48674

June 8, 2012

Ms. Mary Logan
Remediation Project Manager
U.S. Environmental Protection Agency, Region 5
77 West Jackson
Chicago, IL 60604

**Re: Reach MM Final Report-Settlement Agreement-Revision 1 No. V-W-11-C-
974 for The Tittabawassee River/Saginaw River & Bay Site
Dow Submittal Number T2.RMM.2012.001**

Ms. Logan:

Attached please find the revised Final Report for the Reach MM In-Channel Removal Action prepared by The Dow Chemical Company (Dow) for the Tittabawassee River/Saginaw River & Bay Site. Please let me know if you have any questions or concerns.

Sincerely,

A handwritten signature in black ink that reads "Todd Konechne".

Todd Konechne
Project Coordinator
The Dow Chemical Company

CC: Al Taylor, MDNRE
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**Reach MM In-Channel Island Removal Action Final Report
The Tittabawassee River/Saginaw River & Bay Site**



**Prepared by:
Tittabawassee & Saginaw River Team**

**Prepared For and Submitted By:
The Dow Chemical Company**

**June 8, 2012
Dow Submittal Number: T2.RMM.2012.001**

Project Certification

“Under penalty of law, I certify that to the best of my knowledge, after appropriate inquiries of all relevant persons involved in the preparation of the report, the information submitted is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.”



Todd S. Konechne
Project Coordinator

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List of Acronyms

AOC	Administrative Settlement Agreement and Order on Consent
ARARs	applicable or relevant and appropriate requirements
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cy	cubic yards
EE/CA	Engineering Evaluation/Cost Analysis
EPA	U.S. Environmental Protection Agency
GPS	global positioning system
NAVD88	North American Vertical Datum of 1988
NCP	National Contingency Plan
NTCRA	Non-Time Critical Removal Action
TEQ	toxicity equivalent
TOC	total organic carbon

1 Introduction

This Reach MM In-Channel Island Removal Action Final Report (Reach MM Island RA Final Report) provides documentation of a Non-Time Critical Removal Action (NTCRA) that was conducted at the Reach MM In-Channel Island to address actual or potential migration of contaminated sediments from the island into the Tittabawassee River. The NTCRA was performed in accordance with the requirements contained in Section VIII ("Work to be Performed") of the Administrative Settlement Agreement and Order on Consent for the Reach MM Island (Reach MM Island AOC) of the Tittabawassee River (Settlement Agreement No. V-W-11-C-974), and NTCRA Enforcement Memorandum (Action Memorandum; Attachment A of the AOC), effective July 8, 2011.

1.1 Background

The Task 2.1 Technical Memorandum dated July 16, 2010, which was approved by the Agencies in a letter dated September 16, 2010, identified certain in-channel deposits, in-channel center islands, and bank areas for further evaluation. One area, an in-channel center island in Reach MM (Reach MM Island), was identified to be sequenced directly into the Task 2.4 development of potential mitigation measures. As discussed in the Task 2.1 Technical Memorandum and Engineering Evaluation/Cost Analysis (EE/CA), early response actions were proposed for the Reach MM Island in advance of the segment specific Response Proposal for this area. The EE/CA presented three remedial alternatives for the island. The Agencies approved the EE/CA with modification on April 14, 2011. Alternative 2 – Above Water Sediment Removal and In-Place Containment was selected as the remedy and implemented under the Reach MM Island AOC and Action Memorandum in August 2011.

1.2 Objective Of Work

The objective of the selected remedy was to remove island sediments (soil) above the low water line, to cap the remaining island sediments, and to re-establish an island river habitat in advance of the segment-specific response action.

2 Site Description

Reach MM contains four remnant stone piers from a bridge that once existed prior to 1937 (the earliest available aerial photograph of the area). The Reach MM Island likely formed in the early 1900s as a result of geomorphic changes to the river following construction of the bridge piers, and the relatively high logging and agriculture-related sediment loads delivered to the river during this period (ATS 2009). A review of historical aerial photographs (at decade-level temporal scales) revealed that the size of the Reach MM Island decreased since the initial aerial photograph was taken more than 70 years ago. An aerial photograph of the pre-construction island footprint is shown on Figure 1. This portion of the island persisted above the median low water surface (approximate elevation of 579 feet North American Vertical Datum 1988 [NAVD88]) and supported some vegetation.

Furan and dioxins (measured as toxicity equivalent [TEQ] levels) were the primary constituents of interest in sediments on the Reach MM Island. To characterize the distribution of TEQ in the river sediments, 43 samples were collected from the island or in the area immediately surrounding the island, and these samples were used to delineate the extent of TEQ levels in the immediate vicinity of the Reach MM Island to inform the remedial design.

3 Removal Action

As described in and in accordance with the Reach MM In-Channel Island Removal Action Work Plan, dated July 25, 2011 and Addendum 1, Reach MM In-Channel Island Removal Action Work Plan, dated August 17, 2011 the removal action consisted of removing sediment from the emergent portion of the Reach MM Island during dry conditions to an elevation of approximately 579.5 feet NAVD88. The remaining sediments in the vicinity of the Reach MM Island that contained or may potentially contain elevated TEQ levels were confined in-place with an in situ cap (armor cap) comprised of an approximately 1-foot-thick layer of screened natural aggregate. This layer was conservatively designed to resist potential sources of erosion that could impact the stability of the cap. Appendix A presents the armor cap basis of design.

Following placement of the in situ cap, the island was reconstructed using sand and other suitable substrate to promote natural habitat recolonization. The top surface of the sand fill was amended with top soil and the mixed materials placed in a GEOWEB® for stabilization. A layer of cobbles and soils was placed on top of the island to provide structure and promote natural sediment accretion. Finally, indigenous emergent shallow species were planted as plugs on the island.

Each component of the removal action is described below. Appendix F contains a photographic log of the mobilization, removal, and restoration steps outlined in this section.

3.1 Permit Equivalency and Approvals

The removal action at Reach MM Island was performed as a NTCRA under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Though an action performed under formal CERCLA authorities is exempt from the procedural requirements of federal, state, and local environmental laws, the action must nevertheless comply with the substantive elements of applicable or relevant and appropriate requirements (ARARs), in accordance with U.S. Environmental Protection Agency's (EPA's) National Contingency Plan (NCP). Potential applicable or relevant and appropriate requirements (ARARs) and protective measures were considered and addressed or implemented during construction. These protective measures addressed endangered species, regulated wetlands, floodplain impacts, soil erosion and sedimentation control. See Table 1 for specific details pertinent to the ARARs and associated protective measures.

3.2 Site Preparation

Site preparation occurred from August 12 through 18, 2011, and included the following work activities:

- Pre-construction survey and grade control
- Equipment mobilization
- Site access and temporary access road construction
- Temporary bridge construction
- Safety and control features

Site access routes and support areas are shown on Figure 2. Site preparation efforts are described in more detail by work activity in the subsections that follow.

3.2.1 Pre-Construction Delineation Sampling and Surveying

Pre-construction delineation sampling and surveys were conducted in June and July 2011 to delineate the extent of the Reach MM Island. Delineation samples were collected in the channel surrounding the island to delineate the extent of TEQ levels in the immediate vicinity of the Reach MM Island to provide the basis for design. Survey measurements were collected at and around the island using a hand-held global positioning system (GPS) and these measurements were used to delineate the volume of island material above the low water level. Results from the delineation sample and pre-construction survey were presented in the Reach MM Island Work Plan (Dow 2011).

3.2.2 Equipment Mobilization

Equipment mobilization occurred from August 12 through 15, 2011. General construction equipment used at the site included the following:

- Crane and excavator for temporary bridge installation and removal
- Excavator for excavating sediments and placing armor cap
- Front-end loader for handling of capping materials
- Dump trucks for hauling away removed soil/sediment

3.2.3 Site Access and Temporary Access Road Construction

Site access was obtained from three residential properties off Midland Road (Figure 2). A temporary access road was constructed on August 15, 2011, from Midland Road to the River's edge using a woven geotextile overlain with recycled asphalt. Additionally, a laydown area was established on the bank of the River for equipment and materials staging. No removed sediments were staged at the laydown area.

3.2.4 Temporary Bridge

An approximately 144 foot temporary bridge was constructed from the temporary access road to the Reach MM Island between August 16 and 18, 2011. The temporary bridge consisted of a pre-fabricated steel structure (consisting of six components) that was secured to the north bank using H piles driven into the shoreline. The temporary bridge was placed using a crane and excavator on temporary vertical supports (e.g., box culverts) providing a clear span of the river and a clearance of up to approximately 5 feet to allow boat traffic to pass underneath the temporary bridge. The top of the temporary bridge structure was approximately 12 feet in width equipped with guard rails, which allowed for transport of construction equipment to the island. Additionally, lights were placed on bridge to warn boaters of the temporary structure.

3.2.5 Safety and Control Features

Several safety and control features were installed to protect the site workers and mitigate disturbance from the removal action. These features included the following:

- Placement of buoys, reflectors, and both warning and informative signage around the temporary bridge and in-river work area
- Installation of silt curtain around the perimeter of the island
- Installation of silt fence around perimeter of upland access and staging areas
- Daily land surveying of the bridge support structures

In addition to the safety and control features above, dust suppression was implemented, as needed, throughout the duration of the project.

3.3 Sediment Removal And Material Transportation

Excavation activities occurred from August 19 through 21, 2011, and generally proceeded from upstream to downstream. Approximately 135 cubic yards (cy) or 110 tons of island soils/sediments & woody debris were removed from the river above elevation 579.5 feet NAVD88 by an excavator and loaded directly into lined trucks that were positioned at the end of the temporary bridge. Woody debris was removed from and adjacent to the island during the initial removal activities and continued throughout the upstream to downstream progression. The first couple of loads primarily consisted of woody debris generated from the upstream portion of the island and progressively got less as the downstream removal occurred. Approximately one-fifth or 27 cubic yards of debris was included in the 135 cubic yard volume removed. The removed material was transported to People Landfill in Birch Run, Michigan for disposal in compliance with the EPA Off-Site Rule 40 C.F.R. Section 300.400. A summary of landfill manifests is provided in Appendix B.

Following removal, elevation measurements were collected along five transects after removal of the soils/sediments to verify the lateral and vertical limits of the removal.

3.4 Capping and Island Reconstruction

Following removal of the island above elevation 579.5 feet NAVD88, an armor cap was placed according to the work plan and work plan addendum over the remaining sediments and the island was re-constructed above typical water levels. See Figure 5 for the planned and actual footprint of the final constructed armor cap. This section summarizes the activities and conducted to complete the cap and island construction, and includes descriptions of material sampling, cap placement and verification, material quantities, and cap monitoring and maintenance.

3.4.1 Material Sampling

The following three material types were used to construct the cap and the island:

- Natural stone with median diameter (D_{50}) of 2.17 inches for the armor cap
- Silty sand material to construct the island and amended with top soil for habitat establishment on the island
- 3- to 12-inch rounded or sub-angular cobbles to provide stabilization and promote sedimentation on the island

All three materials were obtained from Fisher Sand and Gravel (Mannsiding Road Pit), located in Harrison, Michigan. The habitat material was a blend of a sandy material and topsoil to create a

habitat material with a total organic carbon (TOC) content similar to the TOC content of a representative area in Reach N. Results of the TOC analysis are provided in Appendix C.

3.4.2 Cap Placement and Island Reconstruction

Armor cap placement and island reconstruction activities occurred from August 21 through 24, 2011. The armor cap material was generally placed by an excavator in a 12-inch lift, from downstream to upstream. A transitional layer of armor cap material was placed along the perimeter of the cap to create a natural slope between the vertical extent of the armor cap surface and the river bottom. The average cap constructed thickness was approximately 1 foot (designed for 6-inch to 12-inch) Table 2 contains the cap elevation data and thickness as surveyed during and immediately following its placement. Additional armor cap material beyond the 1-foot cap thickness was necessary to fill a deeper area located on the south side of the island outside of the sediment removal footprint. Approximately 8700 square-feet of surface area are consumed by the armor cap and transition layer, whereas, the proposed footprint of the armor cap was 8660 square-feet. The cap was approximately 184 feet long, and up to 54 feet wide, and the transition zone along the margin of the cap was between 0 to 1 foot thick, being up to four feet wide. (See Figures 6 and 7).

Following armor cap placement, the island was reconstructed in various thicknesses by first mechanically placing the silty sand fill material on top of the armor cap. Next, GEOWEB® (GW-30V-06-08-29 - 6 inches deep x 12 inches wide) was manually placed over the fill material. The GEOWEB® was filled with a combination of fill material amended with topsoil and 3- to 12-inch cobbles to provide stability and promote sedimentation. The 3- to 12-inch cobble material was placed randomly within the GEOWEB® cells prior to the placement of the amended topsoil. Approximately 1850 square-feet of surface area are consumed by the reconstructed island. (See Figures 6 and 7). The reconstructed island, overlying the armor cap, was built to approximately 71 feet long and up to 27 feet wide.

Additionally, 3- to 12-inch cobble material was mechanically placed as a protective barrier on the upstream side and along the perimeter of the reconstructed island. The material was mechanically placed and manually manipulated to create an approximate 12- to 18-inch layer. Approximately 750 square-feet of surface area are consumed by the 3- to 12-inch cobble material on the upstream side and along the perimeter of the reconstructed island.

Finally, a combination of purchased plants and relocated plants from an upstream area were planted in the reconstructed island as plugs. After planting, a cover crop of sterile wheat and hydromulch and tackifier was applied over the soil and plants to promote stabilization until the plants could re-establish their root systems. Approximately 1500 square-feet of surface area are vegetated. See Table 3 for the plant species which were placed on the reconstructed island.

Pre- and post-capping measurements were collected using a hand-held GPS along five transects after cap placement to measure cap thickness. A final elevation survey of the cap was performed on August 23, 2011 in order to verify the cap thickness. Elevations were collected along five transects perpendicular to the flow. Figures 3 and 4 present the elevation survey points, for the armor cap and the reconstructed island. Figure 5 represents the plan and actual footprint of the constructed cap. Figure 6 represents a schematic cross section of each cap and reconstructed

island component. Figure 7 represents the final overlay of all monitoring points for the armor cap and the reconstructed island. Table 2 presents the August and December 2011 measurements for the pre-and post cap elevations and the cap thickness for each of the survey points shown on Figure 3 and 4. As built elevations of the reconstructed island are also contained in Table 2.

3.4.3 Material Quantities

The following table presents a summary of quantities placed as part of the project.

Reach MM Island Material Quantities

Material Type	Materials Placed (tons)	Materials Placed (Cubic Yards)
Armor Cap (1.5-inch gravel)	495 Tons	248 CY
Island Fill Material (Silty Sand)	127 Tons	85 CY
Cobbles (3- to 12-inch)	78 tons	39 CY
Total	700 tons	372 CY

3.5 Site Restoration

Upon completion of work activities, all contractor-related materials and equipment were demobilized from the site by August 31, 2011. Demobilization activities included removal of the following:

- Temporary access road and laydown/staging areas
- Temporary bridge and all support structures
- Heavy equipment
- Site waste and refuse

Following removal of equipment and temporary road, the project area was returned to pre-existing conditions by replacing the topsoil and sod that was removed for the access road and laydown/staging areas. A temporary irrigation system was constructed at the site to water the installed sod and was operated from August through October.

4 Cap Monitoring and Maintenance

The armor cap will be monitored in accordance with the Reach MM Island Monitoring Plan provided in Appendix D. The Reach MM Island Monitoring Plan includes conducting periodic elevation measurements along pre-determined transects to verify the continued performance and protectiveness of the cap. Based on the results of the elevation surveys, follow-on physical cap inspections may be performed to evaluate the integrity of the cap armor. If the monitoring activities indicate that a greater than 6-inch elevation loss of the armor cap has occurred, Dow will notify the agencies within one month of the findings. If further work is needed to ensure the ongoing protectiveness of the cap, Dow will develop a timely plan to address these conditions with the Agencies and submit the plan for Agency review and approval. Construction or maintenance response time-frames will be dependent on weather and river conditions. If necessary, repairs will be completed during the same year that the issue was identified, provided that worker safety can be adequately ensured. Figure 7 contains the survey points on the armor cap and reconstructed island that will be used in future monitoring and maintenance activities.

5 Project Schedule and Estimated Cost

Project work started with site preparation activities beginning August 12, 2011, and concluded with the completion of site restoration on August 31, 2011. The following table presents a summary of the project schedule.

Overall Project Schedule

Activity	Date
Mobilization/Site Preparation	August 12 to 18, 2011
Sediment Removal	August 19 to 21, 2011
Armor Cap Placement and Island Reconstruction	August 21 to 24, 2011
Demobilization/Site Restoration	August 24 to 31, 2011

An estimate of total costs incurred in complying with the AOC is provided in Appendix E.

6 References

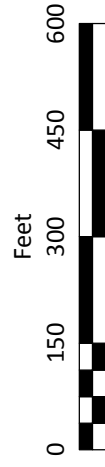
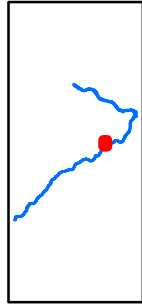
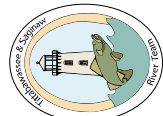
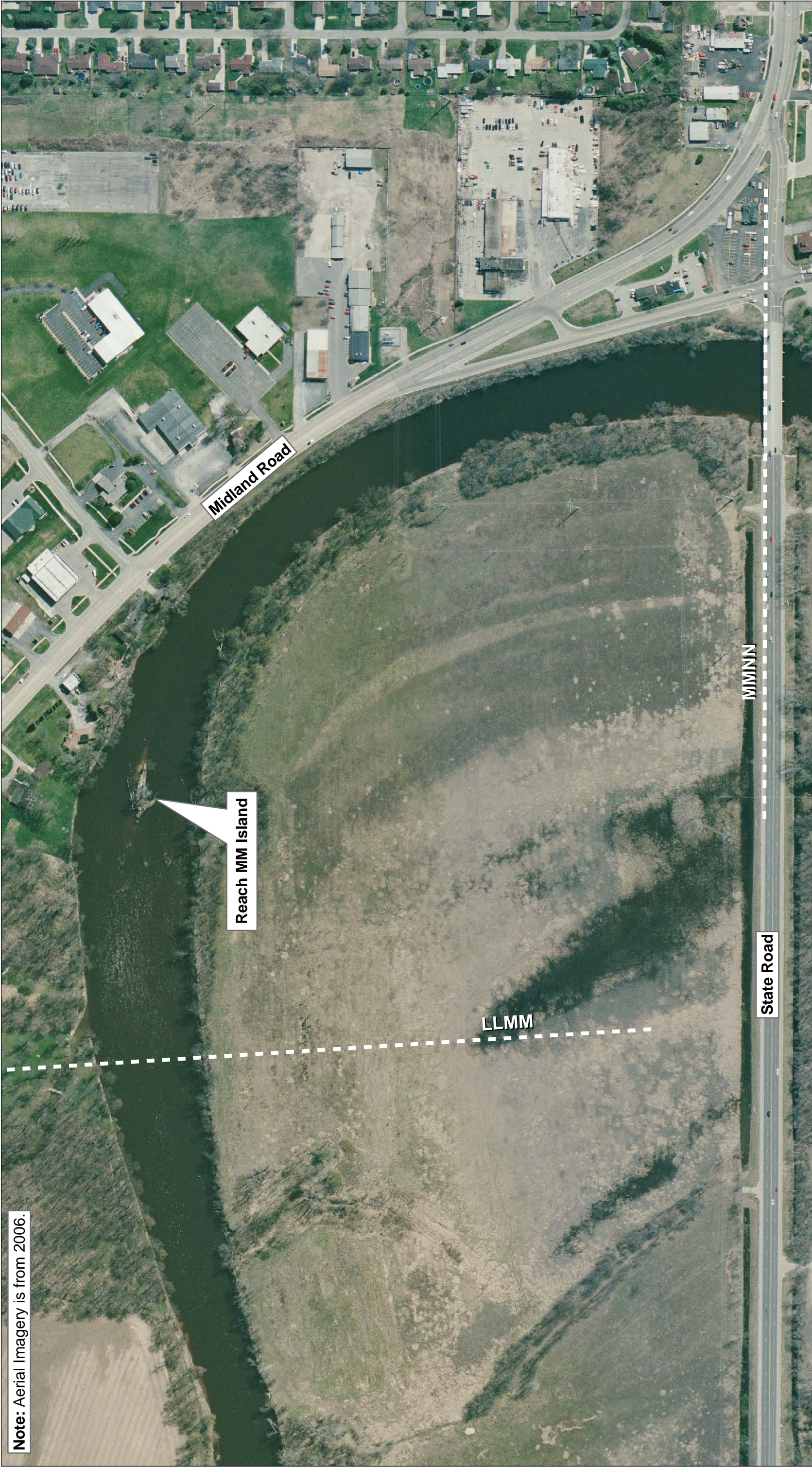
Ann Arbor Technical Services, Inc. (ATS). 2009a. Final GeoMorph Site Characterization Report, Tittabawassee River and Floodplain Soils, Midland, Michigan. June 15.

The Dow Chemical Company (Dow). 2011. Reach MM In-Channel Island Removal Action Work Plan. The Tittabawassee/Saginaw River & Bay Site. July 25.

The Dow Chemical Company (Dow). 2011. Addendum 1 Reach MM In-Channel Island Removal Action Work Plan. The Tittabawassee/Saginaw River & Bay Site. August 17.

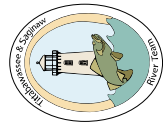
Figures

Note: Aerial Imagery is from 2006.



Site Location
Reach MM Island Removal Action Report

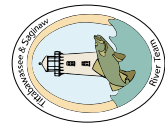
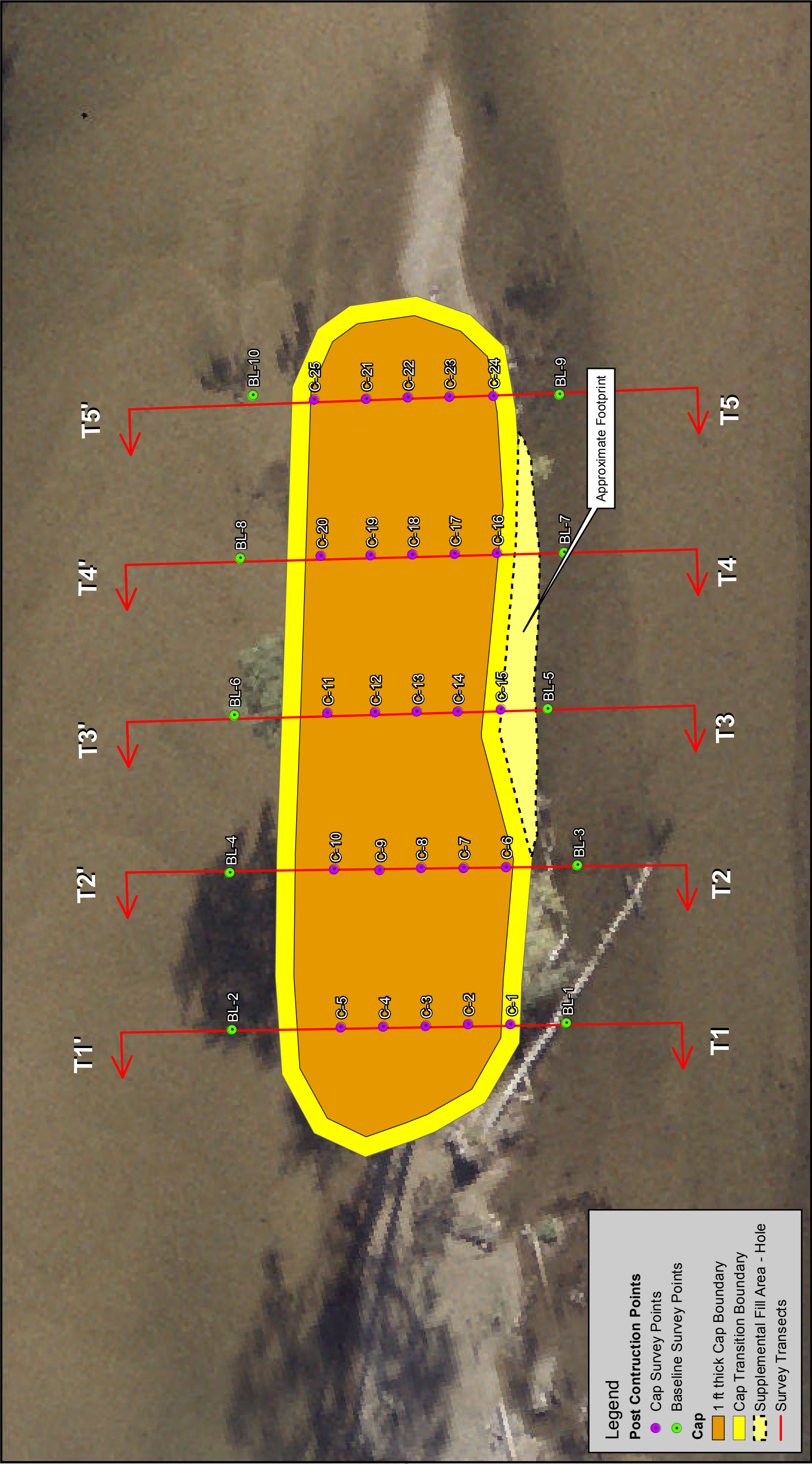
Note: Aerial Imagery is from 2006.



Site Access and Support Areas

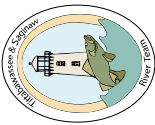
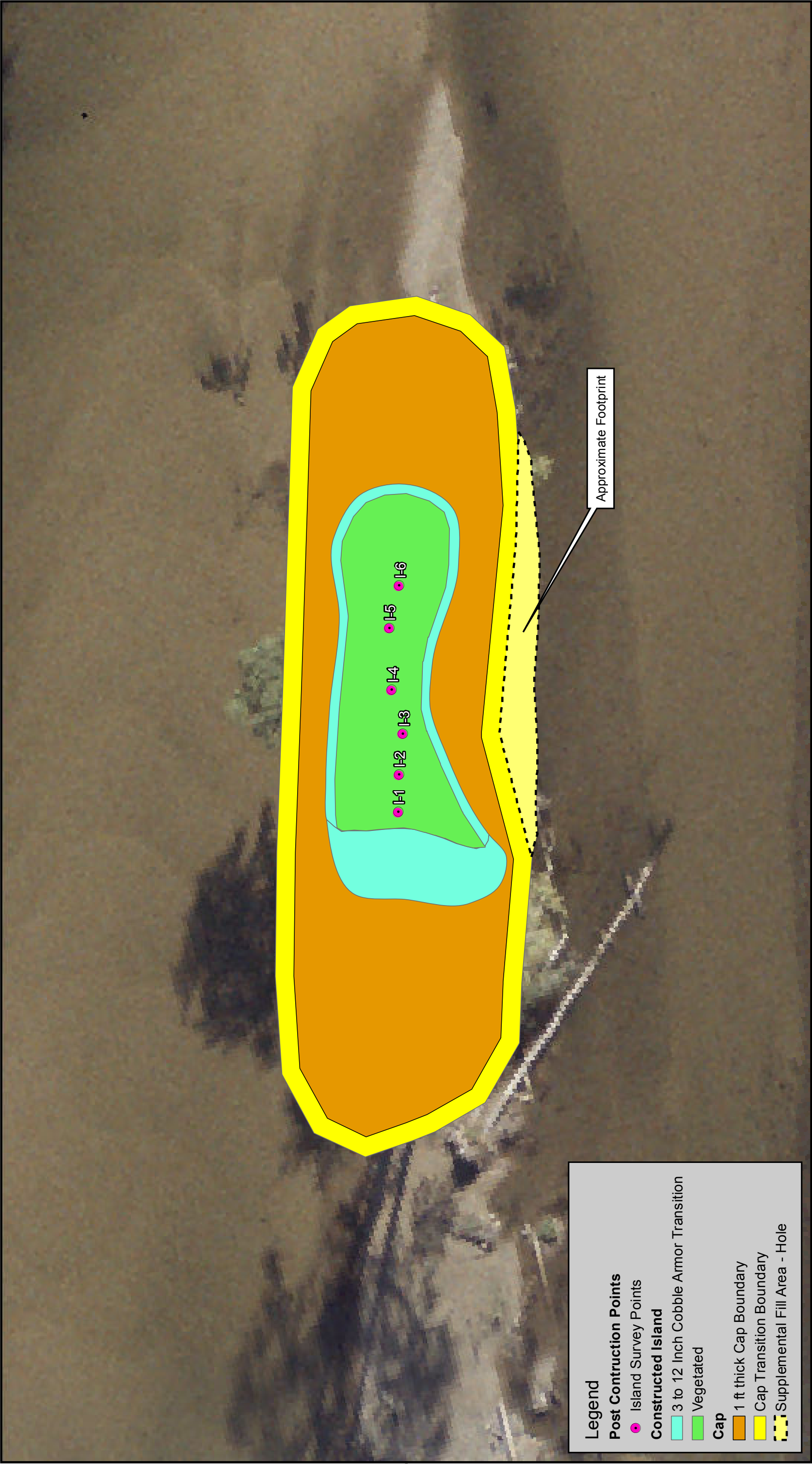
Reach MM Island Removal Action Plan

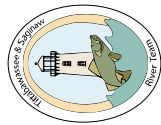
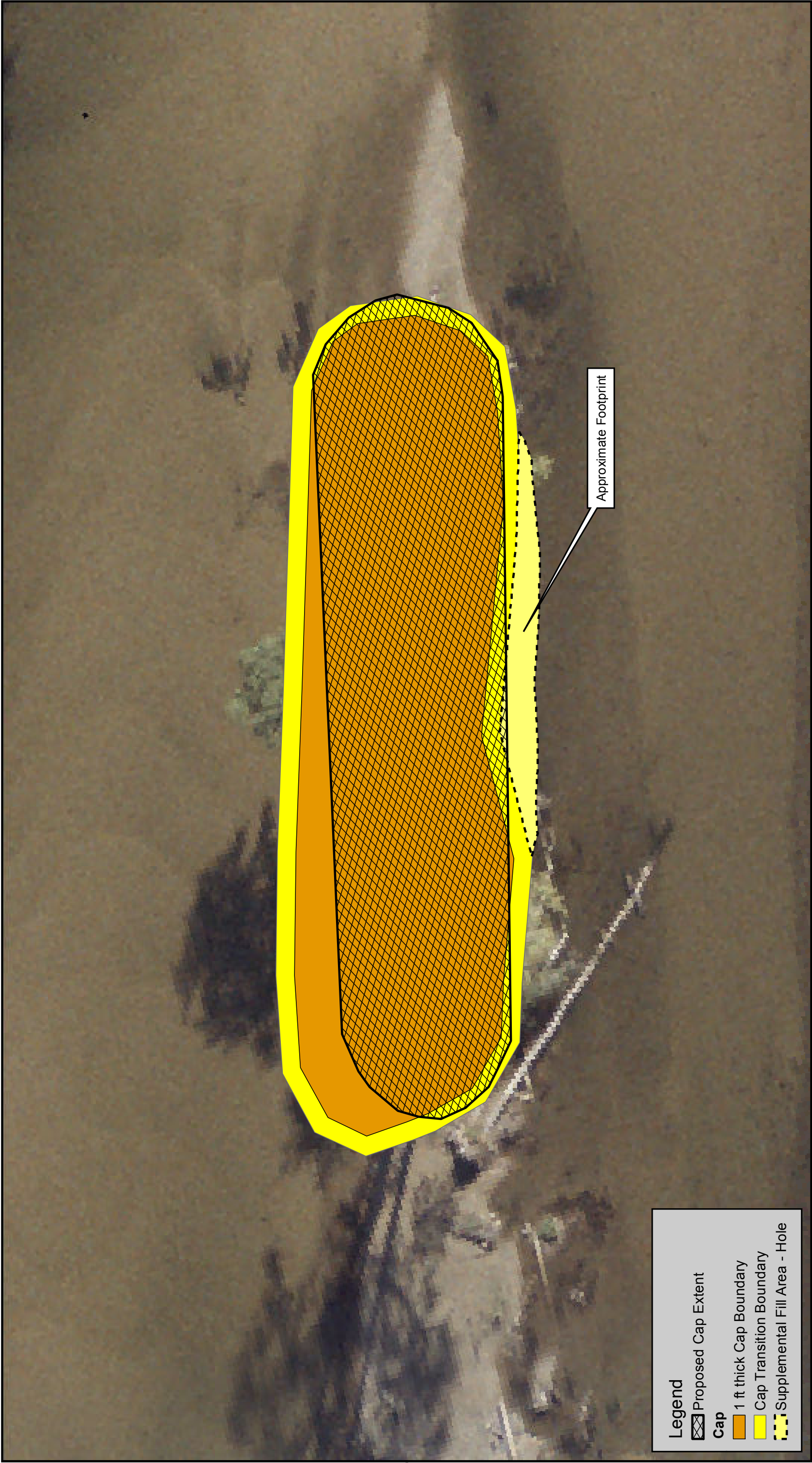
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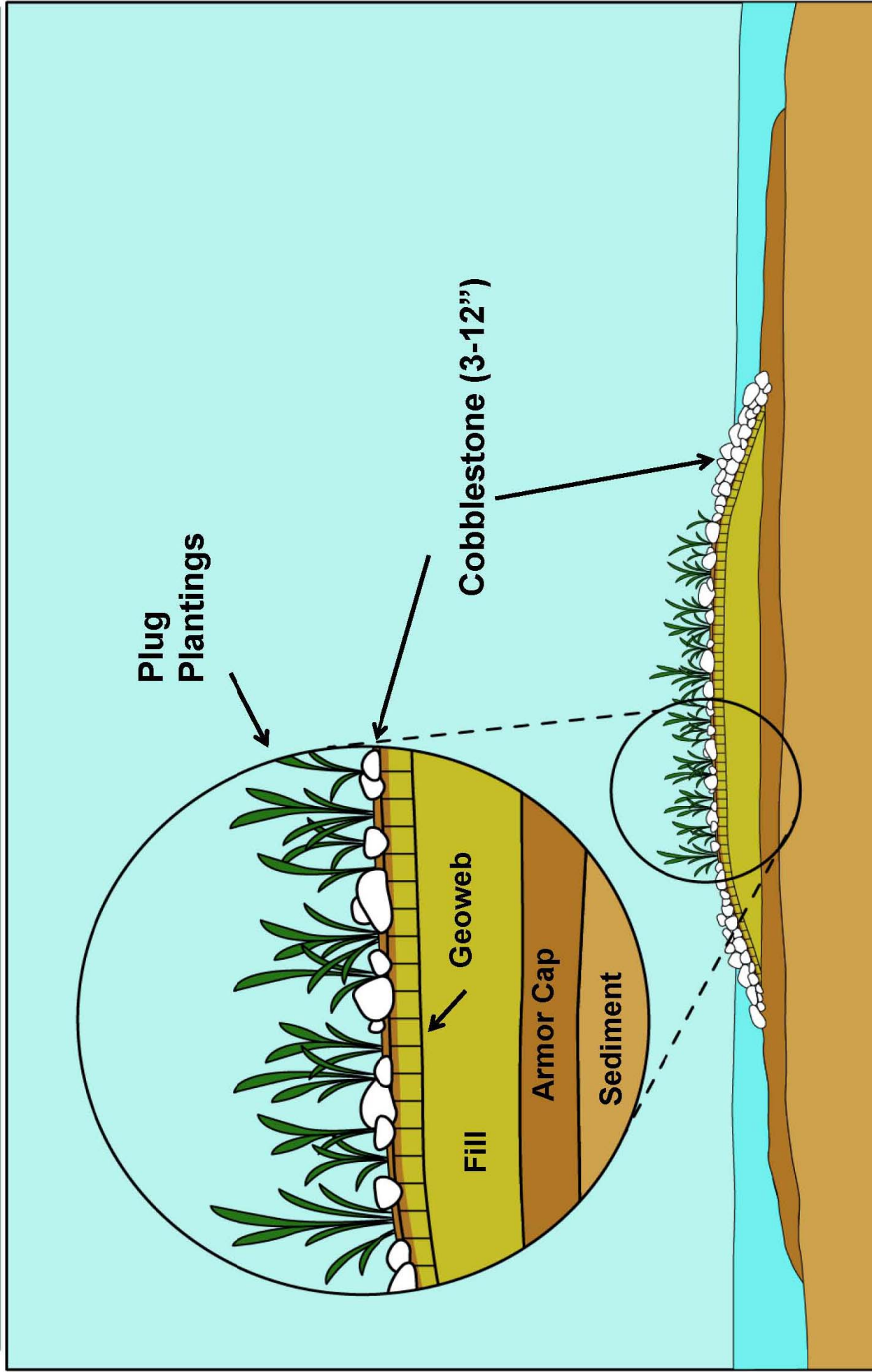


**Post-Construction Armor
Cap Elevation Survey Points**
Reach MM Island Removal Action Report

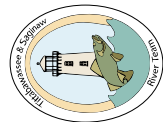
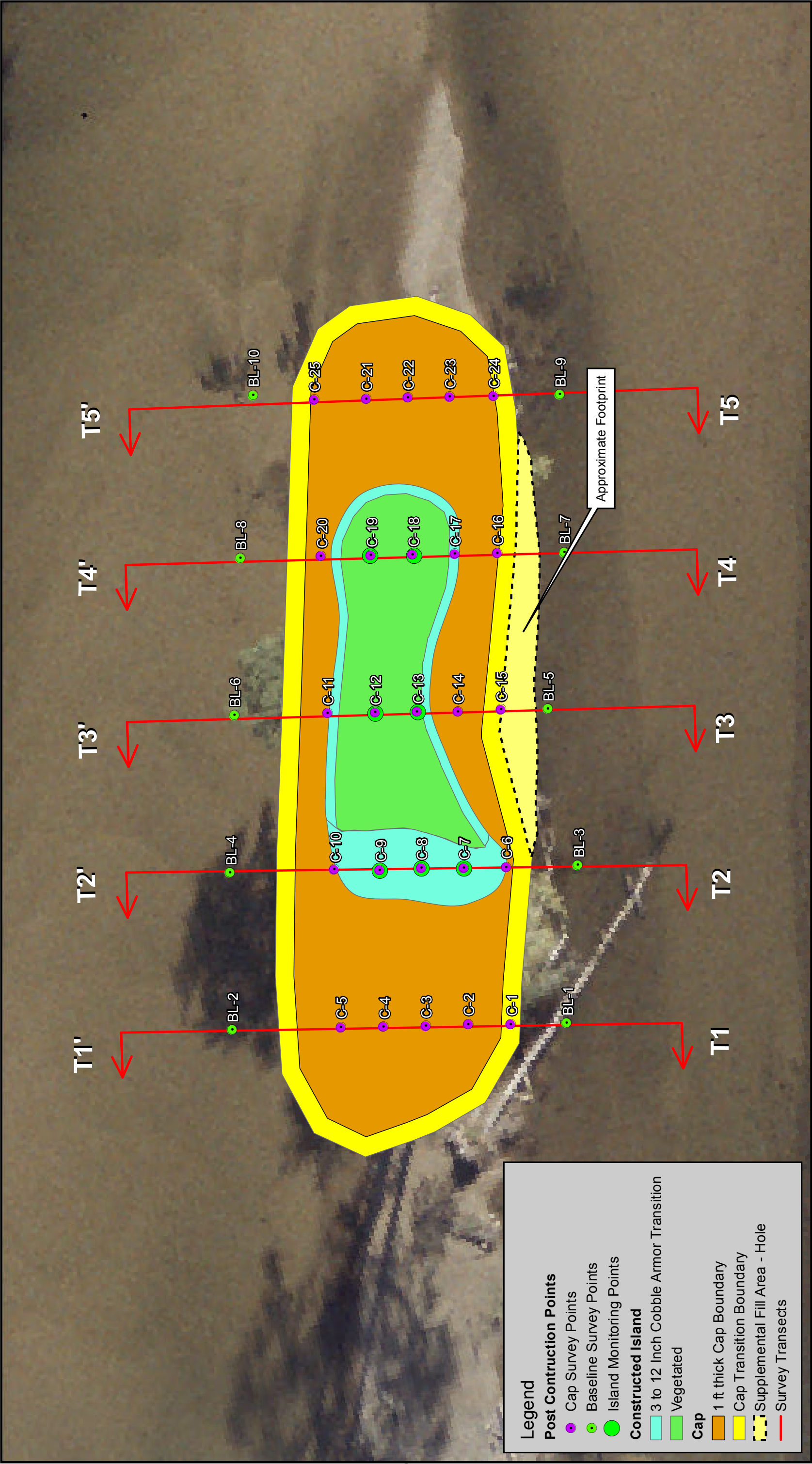








Cap and Island Cross Section
Reach MM Island Removal Action Report



Tables

TABLE 1

Potential ARARs		Protective Measures
Federal ARAR's	Potential Federal Chemical-Specific Requirements or To Be Considered Material (TBCs)	
	1 - A	Clean Water Act - Federal Surface Water Quality Standards
	2 - A	Clean Water Act - Federal Ambient Water Quality Standards
	~Excavation of contaminated soils/sediments performed "in the dry" to minimize potential for releases	
	~Use of cap materials with low % fines to minimize turbidity	
	~Soil Erosion & Sedimentation Control (SESC) - Silt Fence, Silt Curtain in water, Temporary Seeding & Erosion Control Blanket	
	~Environmentally safe fluids in machinery	
	~Crane mats placed on river bottom for equipment travel to prevent sediment disturbance	
	Potential Federal Action-Specific Requirements or TBCs	
	1 - B	Clean Water Act
	2 - B	Resource Conservation and Recovery Act
	3 - B	Endangered Species Act
	Same as 1 - A & 2 - A	
	Manifested shipments of waste	
	No endangered species identified in area	
State ARAR's	Potential Federal Location-Specific Requirements or TBCs	
	1 - C	Floodplain and Wetland Regulations and Executive Orders 11988 and 11990
	2 - C	Clean Water Act
	3 - C	Great Lakes Water Quality Initiative
	4 - C	National Historic Preservation Act
	5 - C	Rivers and Harbors Act
	Hydrodynamic modeling & minimized the amount of temporary fill within the floodplain	
	Same as 1 - A & 2 - A	
	Same as 1 - A & 2 - A	
	No historic or archaeological resources identified in area	
	Same as 1 - A & 2 - A	
State ARAR's	Potential State Chemical-Specific Requirements or To Be Considered Material (TBCs)	
	1 - D	Michigan Water Quality Standards
	Same as 1 - A & 2 - A	
	Potential State Action-Specific Requirements or TBCs	
	1 - E	Soil Erosion and Sedimentation Control
	2 - E	Inland Lakes and Streams
	3 - E	Wetlands Protection
	4 - E	Hazardous Waste Management
	5 - E	Solid Waste Management
	6 - E	Water Resources Protection
	~Soil Erosion & Sedimentation Control (SESC) - Silt Fence, Silt Curtain in water, Temporary Seeding & Erosion Control Blanket	
	~Soil Erosion & Sedimentation Control (SESC) - Silt Fence, Silt Curtain in water, Temporary Seeding & Erosion Control Blanket, A temporary bridge placed on temporary vertical supports to accommodate boat traffic.	
	N/A	
	N/A	
	Manifested shipments of waste	
	Same as 1 - E	
	Potential State Location-Specific Requirements or TBCs	
	1 - F	Soil Erosion and Sedimentation Control
	2 - F	Inland Lakes and Streams
	3 - F	Hazardous Waste Management
	4 - F	Water Resources Protection
	Same as 1 - E	
	Same as 1 - E	
	N/A	
	Utilized site-specific hydrologic model to demonstrate no significant floodplain impacts from cap and reconstructed island.	

Table 2. Post Construction Elevation Survey

Point ID ²	Sediment Elev (Feet) ¹	Final Cap Elev (Feet)	Final Cap Thickness (Feet)	Comments
C-1	579.13	580.11	0.97	
C-2	579.09	580.12	1.02	
C-3	579.48	580.42	0.94	
C-4	579.15	580.10	0.95	
C-5	578.39	579.70	1.31	
C-6	578.69	579.64	0.95	
C-7* ³	579.22	580.19	0.97	12/5/11 top of island elev = 580.63
C-8*	578.97	580.25	1.28	12/5/11 top of island elev = 580.55
C-9*	579.17	580.08	0.90	12/5/11 top of island elev = 580.58
C-10	578.33	579.15	0.82	
C-11	577.10	578.19	1.09	
C-12*	578.41	579.49	1.08	12/5/11 top of island elev = 580.04
C-13*	578.10	578.99	0.90	12/5/11 top of island elev = 580.33
C-14	574.89	577.12	2.23	Hole in river bottom needed filling
C-15	574.75	575.60	0.85	
C-16		577.03		Hole - too deep to survey sediment elev.
C-17	577.15	577.85	0.70	
C-18*	578.98	579.98	0.99	12/5/11 top of island elev = 580.16
C-19*	579.09	579.65	0.56	12/5/11 top of island elev = 580.83
C-20	577.35	578.70	1.35	
C-21	577.73	578.69	0.96	
C-22	579.03	579.92	0.88	
C-23	579.23	580.06	0.83	
C-24	579.40	579.75	0.35	Along the transition of the cap to sediment
C-25	577.77	578.62	0.85	
Average Cap Thickness			0.99	
BL-1	578.24			Baseline elevations - outside cap footprint
BL-2	576.45			Baseline elevations - outside cap footprint
BL-3	578.19			Baseline elevations - outside cap footprint
BL-4	576.93			Baseline elevations - outside cap footprint
BL-5	578.37			Baseline elevations - outside cap footprint
BL-6	576.99			Baseline elevations - outside cap footprint
BL-7	578.61			Baseline elevations - outside cap footprint
BL-8	576.97			Baseline elevations - outside cap footprint
BL-9	576.90			Baseline elevations - outside cap footprint
BL-10	576.59			Baseline elevations - outside cap footprint
I-1		579.90		Surface of island post installation
I-2		579.83		Surface of island post installation
I-3		579.86		Surface of island post installation
I-4		579.96		Surface of island post installation
I-5		580.20		Surface of island post installation
I-6		581.28		Surface of island post installation

1. Suvey data is represented in North American Vertical Datum (NAVD) 88 in feet

2. C = Cap Survey Point; BL = Baseline Survey Point outside cap footprint; I = Post Construction Island survey point. Surveyed on August 23, 2011.

3. C-7 * = Dual purpose monitoring point used for both armor cap and constructed island monitoring. These points were surveyed on December 5, 2011.

MM Island Vegetation Table

	Plant Name - Scientific	Quantity Installed	Date Installed
PURCHASED PLUGS	ASTER NOVAE-ANGLIAE	128	8/24/2011
	CASSIA HEBECARPA	64	8/24/2011
	PHYSOSTEGIA VIRGINIANA	96	8/24/2011
	PYCNANTHEMUM VIRGINIANUM	96	8/24/2011
	SCRIPUS CYPERINUS	128	8/24/2011
	SOLIDAGO RIDDELLII	128	8/24/2011
	SPARTINA PECTINATA	256	8/24/2011
	THALICTRUM DASYPARPUM	96	8/24/2011
	VERNONIA FASCICULATA	128	8/24/2011
	VERBENA HASTATA	96	8/24/2011
RELOCATED PLUGS	SAGITTARIA LATIFOLIA	50	8/24/2011
	CAREX LACUSTRIX	100	8/24/2011
	PANICUM VIRGATUM	50	8/24/2011

Appendix A: Capping Basis of Design Memorandum

MEMORANDUM

To:	Todd Konechne, Dow	Date:	August 26, 2011
From:	Paul LaRosa, P.E., Kim Powell, P.E., and Kyle List, Anchor QEA, LLC	Project:	110559-01
Cc:	Clay Patmont, Anchor QEA, LLC Scott Hayter, Environ		
Re:	Reach MM Island – Tittabawassee River, Basis of Cap Erosion Protection Layer Design		

INTRODUCTION

This memorandum describes the basis of design for an in situ containment cap to physically isolate and stabilize existing contaminated sediment located at the Reach MM Island project area. The cap will be comprised of a physical containment (i.e., erosion protection) layer designed in accordance with U.S. Environmental Protection Agency's (USEPA's) *Guidance for In-Situ Subaqueous Capping of Contaminated Sediments* (Palermo et al. 1998) and other technical guidance documents referenced where appropriate. The erosion protection layer was designed to withstand the natural and human-generated erosive forces that could potentially affect the sediment stability of the Reach MM Island capping area. The potential sources of erosion at the Reach MM Island include the following:

- Hydrodynamic flow
- Wind-induced waves
- Vessel-induced wake waves
- Vessel-induced propeller wash
- Anchor drag
- Ice effects

Each source of potential erosion was evaluated considering site-specific conditions, as described in detail below. The resulting cap design includes a well-graded coarse gravel with a median particle size (D_{50}) of 2 inches.

EROSION PROTECTION LAYER DESIGN

Hydrodynamic Flows

The hydrodynamic model developed for the Tittabawassee River (as described in Appendix C of the Tittabawassee River Segment 1 [OU 1] Response Proposal; Dow 2011) was used to estimate the river flow velocity and the water depth in the vicinity of the Reach MM Island under 100-year flood conditions (flow of approximately 40,000 cubic feet per second [cfs]) using the anticipated post-construction bathymetry. For this simulation, a nominal 1-foot cap thickness was assumed for the proposed cap area.

Two methods were used to estimate the particle size necessary to resist forces generated by hydrodynamic flows. The first method, presented in *Appendix A: Armor Layer Design* (Maynard 1998) of the *Guidance for In-Situ Subaqueous Capping of Contaminated Sediments*, uses velocity and flow depth to determine the stable particle size. Using this method, the median particle size was calculated from the equation (Maynard 1998) below:

$$D_{50} = S_f C_s C_v C_T C_G d \left[\left(\frac{\gamma_w}{\gamma_s - \gamma_w} \right)^{\frac{1}{2}} \frac{V}{\sqrt{K_1 g d}} \right]^{2.5} \quad (\text{Equation 1})$$

where:

- D_{50} = median particle size in feet
- S_f = safety factor, minimum = 1.1
- C_s = stability coefficient for incipient failure = 0.375 for rounded rock
- C_v = velocity distribution coefficient = 1.0 for straight channel and inside of bends
- C_T = blanket thickness coefficient (typically 1 for flood flows)
- C_G = gradation coefficient = $(D_{85}/D_{15})^{1/3}$
- D_{85}/D_{15} = gradation uniformity coefficient (typical range = 1.8 to 3.5)
- d = water depth in feet (from the hydrodynamic model)
- γ_s = unit weight of stone = 165 pounds per cubic foot (lbs/ft³)
- γ_w = unit weight of water = 62.4 lbs/ft³
- V = maximum depth-averaged velocity in feet per second (fps; from the hydrodynamic model)
- K_1 = side slope correction factor

$$g = \text{acceleration due to gravity} = 32.2 \text{ feet per square second (ft/s}^2\text{)}$$

The maximum predicted water velocity near the Reach MM Island for the 100-year flow under post-construction conditions was predicted to be approximately 3 fps and the corresponding depth of flow was approximately 25 feet, based on the OU 1 sediment transport model. Based on these predicted values and appropriate values for the remaining parameters, the stable median particle size estimated by Equation 1 is approximately 0.4 inches.

The second method used to estimate the particle size necessary to resist forces generated by hydrodynamic flows is based on the Shields diagram presented in Vanoni (1975), which presents stable particle sizes under different flow velocities measured parallel to the bed. Using the maximum predicted river velocity value of 3 fps under the 100-year flow, the median particle size was estimated to be approximately 0.5 inches.

Wind-induced Waves

Wind-generated waves are not anticipated to affect the stability of the cap placed at the Reach MM Island, as the narrow width (typically 300 feet or less) and winding nature of the river provides limited fetch distances over which wind-generated waves could develop. Therefore, the erosive forces based on wind-induced waves were assumed to be negligible.

Vessel-induced Wake

The vessel wake analysis was performed for three representative vessels of various hull dimensions that operate in the Tittabawassee River for both recreational use and for commercial charter fishing. The vessels analyzed included the following:

- Ski and Fishing Boat – *Triumph 191*
- Jet Boat – *Smokercraft*
- Sportfishing Boat – *Grady White*

The vessel wake wave height was estimated for each representative vessel using methods defined by Bhowmik et al. (1991). This method estimates vessel wake wave height based on the vessel length, draft, sailing line distance (distance from the vessel to the point of interest), and velocity, and is given by the following empirical relationship:

$$H_m = 0.537V^{(-0.346)}x^{(-0.345)}L_v^{(0.56)}D^{(0.355)} \quad (\text{Equation 2})$$

where:

- H_m = wake wave height in meters
- V = vessel speed in meters per second
- x = vessel sailing line distance in meters
- L_v = vessel length in meters
- D = vessel draft in meters

Each vessel type was evaluated separately under typical operating conditions for the river. Wave wakes were computed for speeds ranging from 5 to 15 miles per hour (mph) and water depths of 2 and 5 feet. The sailing line distance used to determine the maximum wake was conservatively set to 25 feet, which is the minimum distance between the Reach MM Island and the thalweg. The United States Army Corps of Engineers' (USACE) Automated Coastal Engineering System (ACES) Rubble Mound Revetment Design Module was used to compute the stable particle size based on the maximum wake wave height and period. Within ACES, the level of displacement (S) was set to a typical value of 2, which accounts for minor displacement of the erosion protection layer, and a conservatively assumed slope of 5 horizontal to 1 vertical (5H:1V) was used.

Table 1 presents a summary of the vessel wake assessment for the three vessels evaluated. The largest simulated wave was generated by the *Grady White* sportfishing vessel with a wave height of approximately 1.4 feet while traveling at a velocity of 5 mph in 5 feet of water. The maximum wake wave period was estimated to be 1.4 seconds based on maximum wave steepness conditions described in the ACES technical reference. The median stone size (D_{50}) necessary to prevent vessel wake induced erosion was computed to be approximately 2.2 inches for the *Grady White* sportfishing vessel.

Table 1
Summary of Vessel Wake Analysis

Vessel	Vessel Speed (mph)	Water Depth (feet)	Design Hm (feet)	Design Period (seconds)	D ₅₀ (inches)
Ski and Fishing Boat - Triumph 191	5	5	1.0	1.2	1.4
Jet Boat - Smokercraft	5	5	0.9	1.1	1.3
Sportfishing Boat – Grady White	5	5	1.4	1.4	2.2

Note:

Various vessel speeds and water depths were evaluated for each representative vessel. The most conservative vessel-generated wake waves (included in Table 1) resulted from a vessel speed of 5 mph and a water depth of 5 feet for all representative vessels.

Propeller Wash

Based on a review of the Tittabawassee River hydrograph, the flow rate near the Reach MM Island is typically 1,000 cfs or fewer, which will result in a water depth of approximately 1 foot above the cap following construction. Propeller wash is not a concern during these flow conditions because the water is too shallow for vessel operation. However, propeller wash can potentially impact the Reach MM Island capping area during periods of higher flow (greater than approximately 4,000 cfs), which typically occur during spring runoff and generally corresponds to walleye fishing season. Therefore, the stable particle size necessary to withstand the propeller wash forces was estimated assuming a vessel travels over the cap during periods of higher water. The methodology presented by Maynard (1998) in Appendix A of the USEPA guidance (Palermo et al. 1998), was adapted by Anchor Environmental et al. (2007) to evaluate the effects of propeller wash from small recreational vessels under dynamic conditions (i.e., moving vessel as opposed to stationary conditions).

The effects of propeller wash were evaluated for the three representative vessels analyzed for vessel wake as well as a 25-horsepower Sea Ark fishing vessel. The propeller wash model used for this evaluation calculates the propeller wash velocity generated by a vessel accelerating from rest, during which the largest forces from the “jet” of water created by the propeller contact the bed. The initial jet velocity is computed based on the outboard thrust and diameter of the propeller blade using the relationship defined in Blaauw and van de Kaa (1978):

$$U_0 = \frac{1.6}{D_p} \left(\frac{T}{\rho_w} \right)^{0.5} \quad (\text{Equation 3})$$

where:

- U_0 = jet velocity in fps
- D_p = propeller diameter in feet
- T = the vessel thrust in pound-force (lbf)
- ρ_w = is the density of water in slugs per cubic foot (f³)

The jet velocity field based on horizontal and vertical distance (water depth) from the propeller was computed from an adapted form of Equation 6 in Maynard (1998) and is presented below:

$$V_x = 2.78 \times U_0 \times \frac{D_0}{x} \exp \left(-15.43 \left(\frac{z}{x} \right)^2 \right) + V_\theta \quad (\text{Equation 4})$$

where:

- V_x = instantaneous fluid velocity at coordinate x and z in fps
- D_0 = $0.71 D_p$ for non-ducted propeller, $1.0 D_p$ for ducted propeller, in feet
- x = horizontal distance aft of propeller in feet
- z = radial distance from axis of propeller in feet
- V_θ = fluid velocity adjustment factor to account for vessel tilt during acceleration in fps

The jet velocity field values were then translated in time based on the velocity of the vessel. The median grain size able to resist movement caused by the propeller wash was calculated using the method developed by Anchor Environmental et al. (2007) to determine the effective fluid velocity and ultimately the median resistive grain size given by the following equation:

$$D_{50} = \frac{3}{4} C_D \frac{V_{eff}^2}{\frac{\rho_s}{\rho_{fluid}} \left(g C_F + \frac{\alpha V_{eff}}{\Delta t} \right) - g C_F} \quad (\text{Equation 5})$$

where:

D_{50}	=	particle diameter in feet
C_D	=	drag and lift combined coefficient, typically 0.35
V_{eff}	=	effective fluid velocity in fps
ρ_s	=	sediment density in lbs/f ³
ρ_{fluid}	=	fluid density in lbs/f ³
g	=	acceleration due to gravity = 32.2 ft/s ²
C_F	=	coefficient of friction ($\tan \phi$), where ϕ is the friction angle.
α	=	ratio of particle speed to fluid speed at initial motion
Δt	=	duration corresponding to the effective velocity

The median stable particle size was also calculated with the relationship defined in Neill (1973) based only on the effective jet velocity using the following equation:

$$D_{50} = (V_{eff})^{3.5432} \times 0.002 \quad (\text{Equation 6})$$

where:

D_{50}	=	particle diameter in inches at the threshold of motion
V_{eff}	=	effective fluid velocity in fps

The representative vessels were evaluated for typical operating water depths ranging from 3.5 to 5 feet of water. While it is possible the vessels can enter waters shallower than 3.5 feet, it is not anticipated for vessels to operate in a manner requiring bed erosion protection (i.e., only slow accelerations with the propeller lifted to avoid ground contact). The median particle sizes from both methods were compared and the most conservative particle size was selected for design. Table 2 presents a summary of the propeller wash assessment for the four vessels evaluated.

Table 2
Summary of Propeller Wash Analysis

Representative Vessel	Sportfishing – <i>Grady White</i>		Ski and Fishing – <i>Triumph 191</i>		Jet Boat – <i>Smokercraft</i>		25 HP Fishing Vessel – <i>Sea Ark</i>	
Model run	Run #1	Run #2	Run #1	Run #2	Run #1	Run #2	Run #1	Run #2
Total horsepower (HP)	200	200	150	150	90	90	25	25
Water depth (feet)	4	5	4.5	5	4.5	5	3.5	4
Propeller shaft length (feet)	2.08	2.08	2.50	2.50	2.08	2.08	1.67	1.67
Propeller diameter (feet)	1.67	1.67	1.33	1.33	0.33	0.33	0.88	0.88
D ₅₀ (inches)	2.6	0.4	2.5	1.0	3.3	1.7	3.2	1.0

The median particle size necessary for erosion protection of propeller wash was computed to be in the range of approximately 2.5 to 3.3 inches based on the shallow water conditions (3.5 to 4.5 feet) for all representative vessels. When the water depth is deeper for each vessel (4.0 to 5.0 feet), the median particle size is reduced significantly to less than 2 inches for all vessels.

Anchor Drag

Given the shallow water depths during most months, anchoring by recreational vessels is not expected to occur over the Reach MM Island cap. In addition, the cap material will consist of coarse gravel based on the erosion evaluation and it is unlikely that a typical recreational vessel anchor would penetrate significantly into the cap. However, in the unlikely event that a disturbance to the cap occurs as a result of a boat anchor or unintentional grounding, the disturbed area is expected to “self-level” following the removal of the anchor as a result of redistribution of the armor stone caused by the natural hydrodynamics of the river.

Ice Effects

The effects that ice may have on sediment transport in the Tittabawassee River were summarized by Dr. George Ashton in the *Final GeoMorph Site Characterization Report* (SCR; Ann Arbor Technical Services [ATS] 2009). Ashton reported that most types of ice (e.g.,razil ice, anchor ice, and sheet ice) do not pose a threat to sediment stability within the

Tittabawassee River Study Area (see SCR). Ice jamming conditions capable of impacting river bottom sediment stability are, therefore, not anticipated at the Reach MM Island capping area. An upstream ice floe, which was lodged against the Reach MM Island, was documented in aerial imagery taken on February 13, 2009. Similar ice floe lodging could potentially occur at the Reach MM Island post remediation. However, in recent correspondence regarding the Reach MM Island remediation, Dr. Ashton indicated that a median particle size of 2 inches will be protective against erosion from future ice floe events since once the river flow rate exceeds a certain level, the overflow prevents a significant increase in shear stress on the riverbed.

DESIGN SUMMARY

Table 3 summarizes the calculated median particle sizes and material type necessary to resist each of the erosive forces discussed above.

Table 3
Summary of Erosion Protection Layer Design

Analysis Type	Design Median Particle Size (D_{50}) in inches	Material Type
Hydrodynamic flow	0.5	Fine Gravel
Wind-induced waves	Negligible	--
Vessel propeller wash	2.5 to 3.3	Coarse Gravel to Cobble
Vessel wake	1.3 to 2.2	Coarse Gravel
Ice impact	2	Coarse Gravel

Based on the analyses presented above, a well-graded coarse gravel with median particle size of at least 2 inches was selected for the erosion protection layer design to resist erosive forces that may impact the Reach MM Island capping area. Although the propeller wash analysis computed a stable particle size of 2.5 to 3.3 inches (e.g., from a jet boat or *Grady White* boat starting up over the cap with 4 feet of water), the propeller wash calculations contain inherent conservatism resulting from the additive functions to address bottom interactions (Anchor Environmental et al. 2007). Additionally, it is unlikely a vessel would travel over the cap since sufficient water depths for vessel operations occur less than 10% of the time (i.e., primarily during spring runoff). Therefore, a median particle size of at least 2 inches

that meets the predicted erosive forces for hydrodynamic flows, vessel wake, ice impact, and vessel propeller wash in water depths greater than approximately 5 feet was selected. There may be extreme incidences of propeller wash forces that would result in this slightly larger stone (e.g., up to 3.3 inches) than the proposed average 2-inch armor stone. However, these extreme cases are unlikely to occur and, furthermore, the cap material specification includes approximately 30 to 40 percent of particles exceeding 3 inches, which would be protective for those extreme cases.

Table 4 presents the recommended material gradation for the erosion protection layer. It is expected that the actual material used for cap armor will be procured from locally available sources that meet or exceed (i.e., that are larger than required) the design gradation as presented.

Table 4
Armor Layer Stone Specification

U.S. Sieve Size – Percent Passing					
Grain Size	4-inch	2-inch	1-inch	#10	#200
Maximum	100	50	40	15	2
Minimum	90	30	15	5	0

The recommended minimum thickness of the erosion protection layer based on propeller wash (the controlling force from an erosion standpoint) is one and a half times the maximum stone size ($1.5 \cdot D_{100}$) or 2 times the median stone size ($2 \cdot D_{50}$), whichever is greater (Maynard 1998). Using the recommended gradation (Table 4), the minimum thickness is 6 inches, calculated as one and a half times the maximum stone size of 4 inches. Therefore, considering reasonable overplacement of the erosion protection layer during construction, an armor cap thickness of 6 to 12 inches is anticipated.

REFERENCES

Anchor Environmental, LLC, Coast & Harbor Engineering, and Shaw, 2007. *Propwash Modeling Approach to Support Optimized Remedy Cap Design*. Prepared by Anchor Environmental, LLC, Coast & Harbor Engineering, and Shaw. January 15, 2007.

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- Bhowmik, N.G., Soong, T.W., Reichelt, W.F., and Seddik, N.M.L., 1991. *Waves Generated by Recreational Traffic on the Upper Mississippi River System*. Research Report 117. Department of Energy and Natural Resources, Illinois State Water Survey, Champaign, IL.
- Blaauw, H. G., and E. J. van de Kaa. 1978. Erosion of Bottom and Sloping Banks Caused by the Screw Race of Maneuvering Ships. Paper presented at the 7th International Harbour Congress, Antwerp, Belgium. May 22-26, 1978.
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- Maynard, S. 1998. *Appendix A: Armor Layer Design for the Guidance for In-Situ Subaqueous Capping of Contaminated Sediment*. Prepared for the U.S. Environmental Protection Agency (USEPA).
- Neill, C.R. 1973. *Guide to Bridge Hydraulics*. University of Toronto Press.
- Palermo, M., S. Maynard, J., Miller, and D. Reible, 1998. *Guidance for In-Situ Subaqueous Capping of Contaminated Sediments*, EPA 905-B96-004, Great Lakes National Program Office, Chicago, IL.
- United States Army Corps of Engineers (USACE), 1992. *Automated Coastal Engineering System (ACES)*. Technical Reference by D.E. Leenknecht, A. Szuwalski, and A.R. Sherlock, Coastal Armor Layer Design for Vessel-Generated Waves Engineering Center, Department of the Army, Waterways Experiment Station, Vicksburg, MS.
- Vanoni, V.A., 1975. *Sedimentation Engineering*. ASCE Manuals and Reports on Engineering Practice, No. 54, 730 pp.

Appendix B: Summary of Landfill Manifests

Reach MM Island Sediment Removal Manifest Tracking Log

#	Company Name	Truck #	Manifest #	Date	Quantity (CY)	Date Loaded	Date Delivered	Removal Location
1	Fisher Transport	160	00627953	8/20/2011	15	8/19/2011	8/20/2011	Island Sediment
2	Fisher Transport	161	00627952	8/20/2011	15	8/19/2011	8/20/2011	
3	Fisher Transport	297	00627954	8/20/2011	15	8/20/2011	8/20/2011	
4	Fisher Transport	312	00627955	8/20/2011	15	8/20/2011	8/20/2011	
5	Fisher Transport	293	00627956	8/20/2011	15	8/20/2011	8/20/2011	
6	Fisher Transport	314	00627957	8/20/2011	15	8/20/2011	8/20/2011	
7	Fisher Transport	295	00627958	8/20/2011	15	8/20/2011	8/20/2011	
8	Fisher Transport	314	00627959	8/21/2011	15	8/21/2011	8/22/2011	
9	Fisher Transport	295	00627960	8/21/2011	15	8/21/2011 & 08/22/11	8/22/2011	
Total Island Sediment Removed					135			
10	Fisher Transport	291	00627961	8/29/2011	15	8/29/2011	8/29/2011	Floodplain Soils
11	Fisher Transport	291	00627962	8/29/2011	15	8/29/2011	8/29/2011	
12	Fisher Transport	314	00627963	8/29/2011	15	8/29/2011	8/29/2011	
13	Fisher Transport	291	00627964	8/29/2011	15	8/29/2011	8/29/2011	
14	Fisher Transport	314	00627965	8/29/2011	15	8/29/2011	8/29/2011	
15	Fisher Transport	291	00627966	8/29/2011	15	8/29/2011	8/29/2011	
16	Fisher Transport	314	00627967	8/30/2011	15	8/30/2011	8/30/2011	
17	Fisher Transport	314	00627968	8/30/2011	15	8/30/2011	8/30/2011	
Total Floodplain Soils Removed					120			

Footnotes

1. Woody debris was mixed in with sediment loads throughout shipment. Approximately 27 cubic yards of woody debris was removed from the island
2. Approximately 90 percent of temporary fill (recycled asphalt) was recycled and shipped to Fisher Contracting's Waldo Road Yard. Floodplain soils were the top 4 inches (+/-) of existing sod/soil and woven geotextile. These floodplain soils were removed to accommodate the thickness of the new sod and transition into the surrounding grades.

Appendix C: Construction Documentation

McDowell & Associates

Geotechnical, Environmental & Hydrogeological Services • Materials Testing & Inspection

3730 James Savage Road • Midland, MI 48642

Phone (989) 496-3610 • Fax (989) 496-3190

August 16, 2011

Fisher Contracting
614 Jefferson Avenue
Midland, Michigan 48640

Job No. 11-68314

Attention: J.W. Fisher

Subject: Soil Testing
Reach "MM"
Dow Chemical Company
Midland, Michigan

Dear Mr. Fisher,

In accordance with your request, we have performed the soil tests on the samples from the aforementioned project as provided by you. Selected samples were tested for Total Organic Content, Fractional Organic Carbon and Gradation Testing.

Sample ID	Organic Content	Fractional Organic Carbon*
2 NS	1.26 %	0.731 %
Class II	0.99 %	0.577 %
Topsoil	2.93 %	1.697 %

* Indicates an estimation based on industry standard (Semi-Quantitative). If hard data is required, full analytical (Qualitative) testing should be completed.

Results of Gradation Testing are attached.

If you have any questions, or if we can be of further service, please feel free to call.

Respectively Submitted,

McDOWELL & ASSOCIATES



Michael S. Keenan, P.E.
Project Engineer

Southeast Michigan Office

21355 Hatcher Avenue • Ferndale, MI 48220

Phone: (248) 399-2066 • Fax: (248) 399-2157

SIEVE ANALYSIS

ASMT C 136-05

Project Name: Reach MM

Project No.: 11-68314

Client: Fisher Contracting

Sample No.: 11-423

Sample Date: August 12, 2011

Sampled By: Client

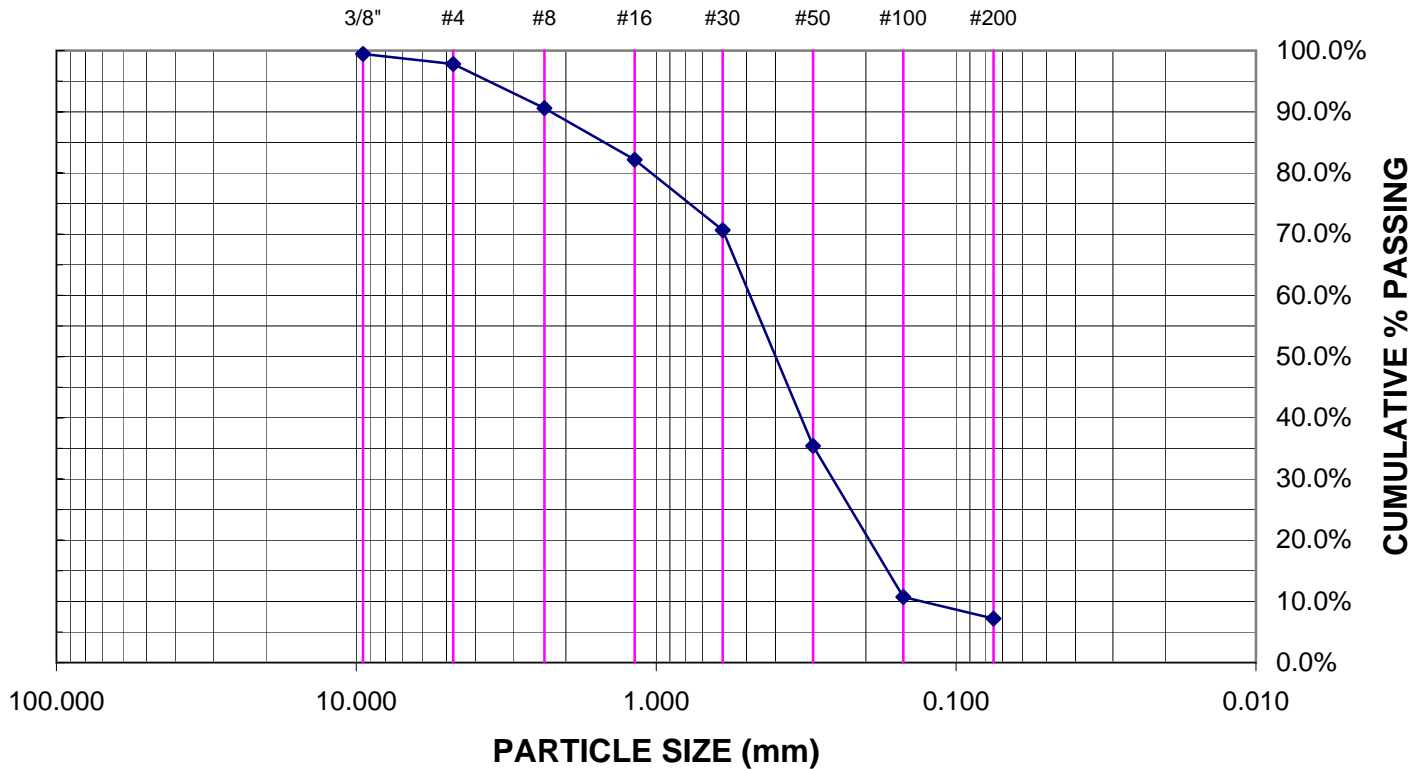
Tested Date: August 16, 2011

Performed By: Mike Keenan

Source: 2 NS

Material Description: Brown SAND

GRAIN SIZE DISTRIBUTION



D₈₀: 1.04 mm

% Passing 3/8" Sieve: 99.4%

% Passing #30 Sieve: 70.7%

D₆₀: 0.49 mm

% Passing #4 Sieve: 97.8%

% Passing #50 Sieve: 35.4%

D₅₀: 0.40 mm

% Passing #8 Sieve: 90.6%

% Passing #100 Sieve: 10.7%

D₃₀: 0.26 mm

% Passing #16 Sieve: 82.2%

% Loss by Wash: 7.2%

D₁₀: 0.13 mm

Remarks: _____

SIEVE ANALYSIS

ASMT C 136-05

Project Name: Reach MM

Project No.: 11-68314

Client: Fisher Contracting

Sample No.: 11-424

Sample Date: August 12, 2011

Sampled By: Client

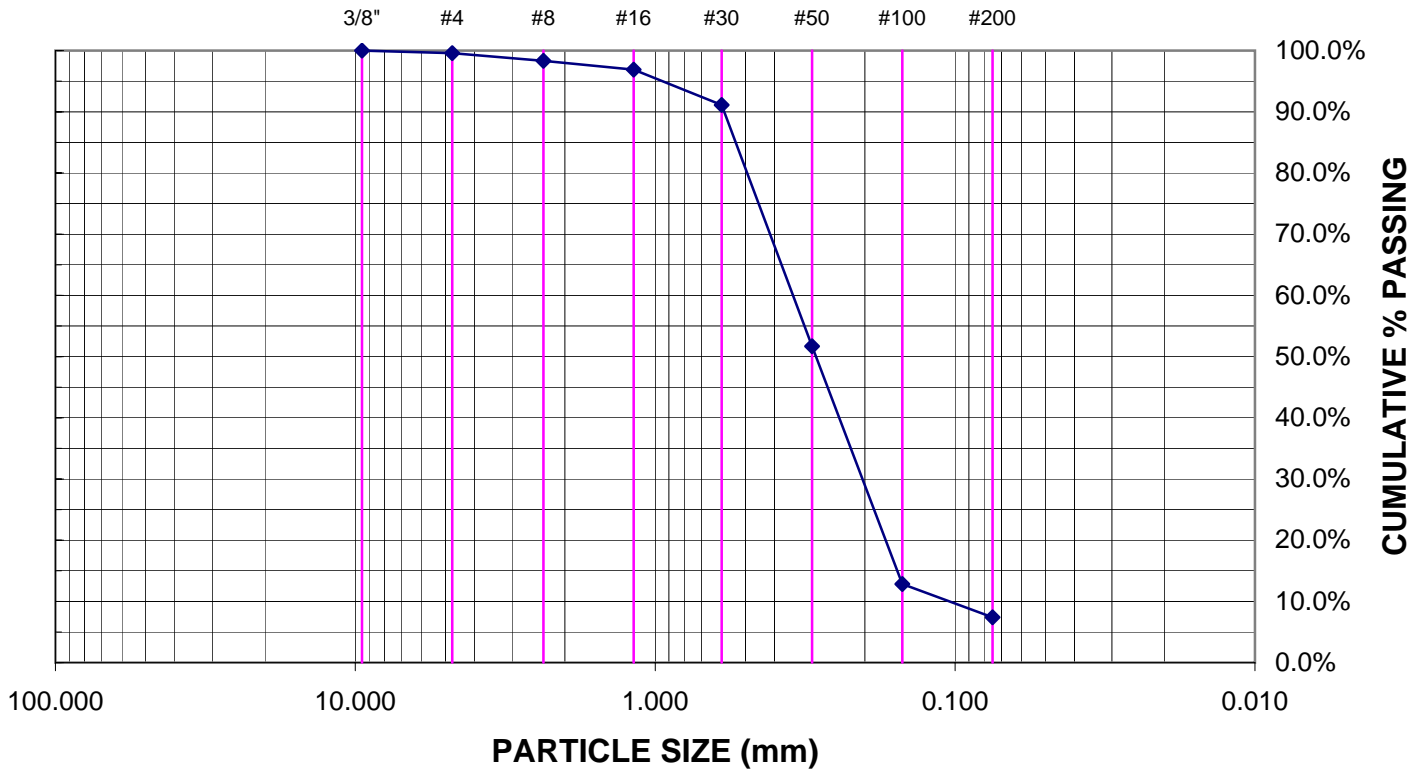
Tested Date: August 16, 2011

Performed By: Mike Keenan

Source: Class II

Material Description: Brown SAND

GRAIN SIZE DISTRIBUTION



D₈₀: 0.49 mm

% Passing 3/8" Sieve: 100.0%

% Passing #30 Sieve: 91.1%

spec: 100%

spec: 20% - 55%

D₆₀: 0.35 mm

% Passing #4 Sieve: 99.6%

% Passing #50 Sieve: 51.7%

spec: 95% - 100%

spec: 10% - 30%

D₅₀: 0.29 mm

% Passing #8 Sieve: 98.3%

% Passing #100 Sieve: 12.8%

spec: 65% - 95%

spec: 0% - 10%

D₃₀: 0.20 mm

% Passing #16 Sieve: 96.9%

% Loss by Wash: 7.4%

spec: 35% - 75%

spec: 0% - 3%

D₁₀: 0.10 mm

Remarks: _____

SIEVE ANALYSIS

ASMT C 136-05

Project Name: Reach MM

Project No.: 11-68314

Client: Fisher Contracting

Sample No.: 11-425

Sample Date: August 12, 2011

Sampled By: Client

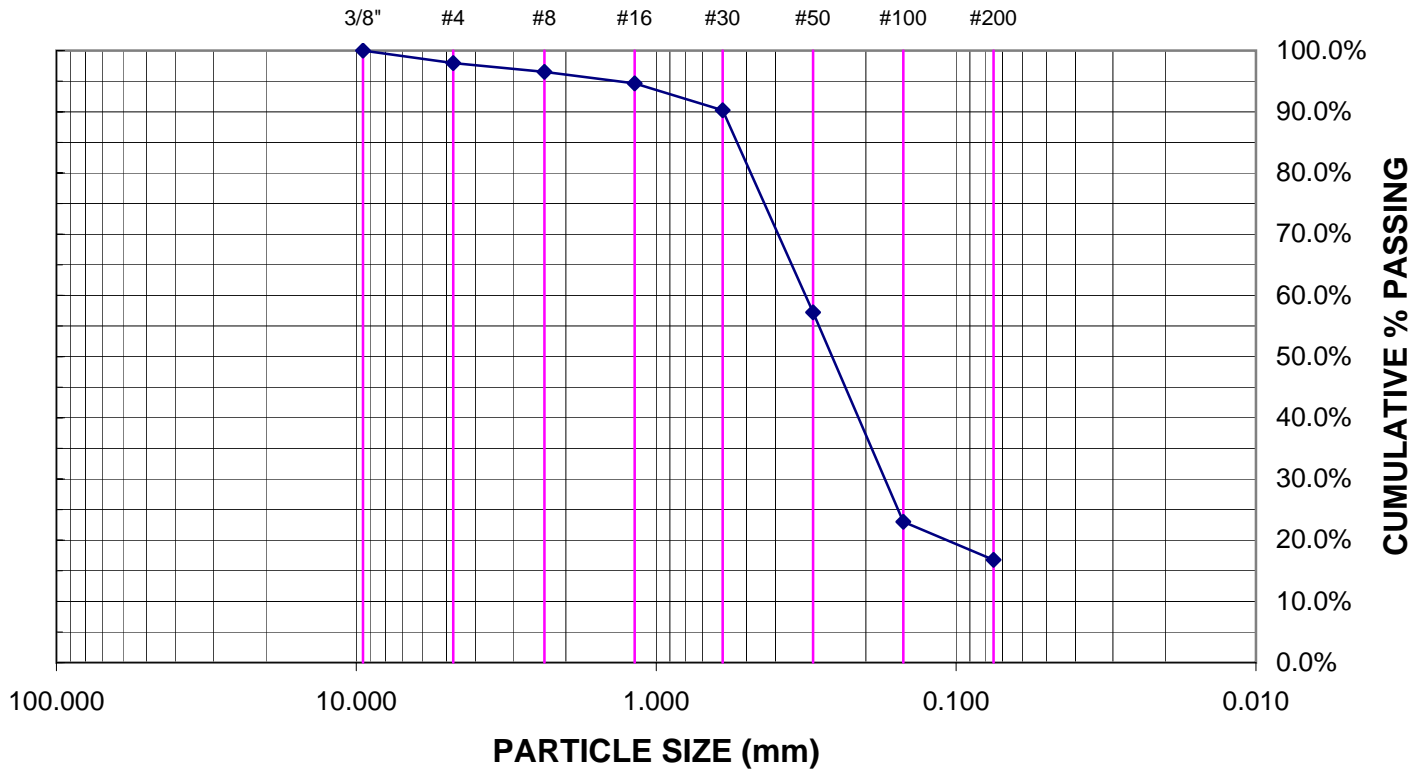
Tested Date: August 16, 2011

Performed By: Mike Keenan

Source: Topsoil

Material Description: Brown SAND with clay and organics

GRAIN SIZE DISTRIBUTION



D₈₀: 0.48 mm

% Passing 3/8" Sieve: 100.0%

% Passing #30 Sieve: 90.2%

D₆₀: 0.32 mm

% Passing #4 Sieve: 98.0%

% Passing #50 Sieve: 57.2%

D₅₀: 0.26 mm

% Passing #8 Sieve: 96.5%

% Passing #100 Sieve: 23.0%

D₃₀: 0.17 mm

% Passing #16 Sieve: 94.6%

% Loss by Wash: 16.8%

D₁₀: ~0.04 mm

spec: 35% - 75%

spec: 0% - 3%

Remarks: _____

Appendix D: Reach MM Island Monitoring Plan

**Reach MM In-Channel Island Monitoring Plan
The Tittabawassee River/Saginaw River & Bay Site**



**Prepared By:
Tittabawassee & Saginaw River Team**

**Prepared For and Submitted By:
The Dow Chemical Company**

June 8, 2012

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Table 1: Reach MM Island Monitoring Schedule

Table 2: Post-Construction Elevation Survey

ACRONYMS AND ABBREVIATIONS

AOC	Administrative Settlement Agreement and Order on Consent
GPS	global positioning system
NAVD88	North American Vertical Datum of 1988
NTCRA	Non-Time Critical Removal Action
TEQ	toxicity equivalent
TOC	total organic carbon

1 Introduction

A Non-Time Critical Removal Action (NTCRA) was conducted at the Reach MM In-Channel Island to address potential migration of contaminated sediments from the island into the Tittabawassee River. The NTCRA was performed in accordance with the requirements contained in Section VIII ("Work to be Performed") of the Administrative Settlement Agreement and Order on Consent for the Reach MM Island (Reach MM Island AOC) of the Tittabawassee River (Settlement Agreement No. V-W-11-C-974), and the NTRCA Enforcement Memorandum (Action Memo; Attachment A of the AOC), effective July 8, 2011.

The removal action was conducted in August 2011. The work performed is summarized in the Reach MM Removal Action Final Report (Dow 2011). Approximately 135 cubic yards of sediment were removed under dry conditions from the emergent portion of the Reach MM Island to an elevation of approximately 579.5 feet North American Vertical Datum of 1988 (NAVD88). The remaining sediments in the vicinity of the Reach MM Island that contained or may potentially contain elevated dioxin toxicity equivalent (TEQ) levels were confined in-place with an in situ cap (armor cap).

The armor cap is comprised of an approximately 12-inch-thick layer of armor stone. This armor layer was conservatively designed to prevent erosion that could impact sediment stability. Approximately 8800 square-feet of surface area are consumed by the armor cap and transition layer, whereas, the proposed footprint of the armor cap was 8660 square-feet. (See Figures 1 through 4). An island was then constructed using sand and other suitable substrate to promote natural habitat recolonization. The top surface of the sand fill was amended with top soil to promote revegetation and the mixed material placed in a GEOWEB® for stabilization. A layer of cobbles and habitat soils was placed on top of the constructed island to provide structure and promote natural sediment accretion. Approximately 1850 square-feet of surface area are consumed by the reconstructed island.

Finally, natural perennial aquatic species were planted as plugs on the island. The island habitat covered approximately 17% of the armor cap (See Figure 3).

This Reach MM Island Monitoring Plan describes the specific monitoring activities that will be conducted to verify that the in situ containment cap continues to function as designed. The remainder of this Monitoring Plan is organized as follows:

- Section 1 provides the baseline environmental condition of the Reach MM Island as well as the cap monitoring data quality objectives;
- Section 2 describes the scope of work for the post-construction monitoring;
- Section 3 provides the reporting information and schedule;
- Section 4 discusses additional investigations and maintenance activities that will be performed if a sediment cap performance criterion is exceeded; and
- Section 5 presents the reference citations.

1.1 Baseline Environmental Conditions at the Reach MM Island Cap Area

The Reach MM removal action was based on a detailed characterization of sediment conditions near the island as described in the Reach MM Island Removal Action Work Plan (Dow 2011). As described above, following removal of the emergent portion of the Reach MM Island, an in situ containment cap was placed over remaining sediments in the immediate vicinity of the island. An island was also reconstructed to provide habitat diversity. A baseline elevation survey was conducted on August 23, 2011 and December 5, 2011 to measure the post-construction cap elevations. The post-construction topographic survey monitoring points have been renumbered for future monitoring use and are presented on Figures 3, 4, and 5.

1.2 Objectives

The overall objective of this Reach MM Island Monitoring Plan is to ensure the long-term integrity and protectiveness of the cap placed over the Reach MM Island area. The placement of the armor cap is intended to provide stability to the island habitat and underlying sediments; therefore, the long-term effectiveness of the cap is dependent on monitoring the physical integrity of the armor cap.

2 Scope of Work

Monitoring of the Reach MM Island armor cap and island habitat will consist of physical integrity monitoring, which will include two elements:

- Elevation surveys and monitoring
- Physical cap inspections (as needed)

Routine elevation surveys of the cap and island will be performed to evaluate the stability of the cap over time. When the island was reconstructed, the material used to construct the habitat island was placed over the armor stone for a portion of the Reach MM cap. Therefore, changes in the island elevation will not indicate a corresponding change in the elevation of the cap under the island (e.g., erosion of the reconstructed island should not be construed as erosion of the underlying cap). A measured reduction in surface elevation of greater than 6 inches relative to the baseline post-construction elevation survey in the cap and reconstructed island areas, will trigger further evaluation (e.g., physical cap and island inspection) to determine if the armor cap has retained its design thickness and coverage and to determine if there is a changes in the island that should be noted. Some minor elevation loss due to settlement of the underlying sediments is expected.

The elevation surveys will be routinely conducted according to the monitoring schedule summarized below or performed on an event-driven basis if a greater than 15,000 cubic feet per second (cfs) flow event occurs:

Table 1. Reach MM Island Monitoring Schedule

Monitoring Component	Schedule	Cap Inspection Threshold ²
Elevation Survey	Spring/Summer 2012	Reduction in cap elevation greater than 6 inches ³
	Spring/Summer 2013	
	Spring/Summer 2015	
	After 2015 ¹	
	Event Driven - Following a greater than 15,000 cfs flow event ¹	

Table notes:

1. The long-term elevation survey frequency beyond year 2015 will be developed after evaluation of 2012 through 2015 monitoring data and in consideration of the segment-specific final response action.
2. If the elevation of the armor cap has decreased by greater than 6 inches relative to post-construction baseline conditions, an inspection of the cap area will be performed.
3. If the elevation of the reconstructed habitat island elevation has decreased by greater than 6 inches relative to the post construction baseline conditions, an inspection of the reconstructed island area will be performed.

Details of the elevation survey and visual cap inspection techniques are discussed in the following sections.

2.1 Elevation Surveys and Monitoring

The elevation of the armor cap and island habitat will be measured using a handheld differential global positioning system (GPS). Standard GPS survey practices, such as pre- and post-survey benchmark checks will be made to ensure accurate elevation measurements. Surface elevations of the cap will be measured along five transects, the surface elevation of the island will be measured along three of the five transects consistent with the post cap elevation survey performed at the completion of construction (Figure 5). Survey points will remain at the same locations for successive monitoring events (determined by GPS horizontal coordinates) to accurately characterize elevation changes over time.

Armor cap surface elevation measurements will be compared to 2011 post-construction baseline cap measurements at survey points indicated by C1 – C25 (See Table 2). The reconstructed island was placed on top of the Reach MM cap, covering the armor stone and subsequently covers several monitoring points. At the locations where the island material covers the cap survey points, the survey conducted will still be compared to the post-construction cap heights to confirm the cap is still in place. In these locations, the elevation will represent both the cap and the island thickness, and as long as the total thickness does not reflect a loss of 6 inches of cap based on the pre and post cap measurements, the cap will be considered in-tact. An evaluation of the data and visual observations will determine whether the island material is still present above the top of cap elevation. If an elevation loss greater than 6 inches of the armor cap is detected at three or more contiguous locations in any direction, relative to the baseline survey, a physical inspection will be performed to determine if erosion of the cap has

occurred or there is a shifting or settling of the entire cap. A loss of 6 inches represents a conservative number because the minimum cap thickness required is 6 inches and an average cap placement was approximately 12 inches.

Island surface elevations measurements will be taken at 7 existing survey stations, and will be compared to 2011 post-construction baseline island measurements (See Table 2 and Figure 5). If an elevation loss of greater than 6 inches is identified on the reconstructed island, a physical inspection of the island material will be performed to determine the condition of the island and ensure erosion of the underlying cap is not occurring. The physical island inspection will be documented and referenced for future inspections.

Minor elevation loss of 6 inches or less that occurs over multiple measurement points on the cap and island can be attributed to measurement accuracy and/or settling of the underlying sediments. If elevation differences between successive monitoring measurements show an increase in elevation (along with visual observation of accumulated fine-grained and sandy sediments), the cap and reconstructed island is likely accreting sediment.

2.2 Physical Cap and Island Inspections

Elevation surveys will be supplemented by physical inspections for areas within the cap footprint where measurements indicate greater than 6 inches of apparent reduction at three or more contiguous survey locations relative to the post-construction baseline survey. Cap and/or island inspections will include physical survey of the cap/island areas of interest using GPS and an estimation of armor thickness using manual probing, in areas outside the footprint of the reconstructed island. Photographic documentation will also be included in the Island Monitoring/Inspection program. Response actions based on the results of the physical survey include:

- If cap inspections indicate that the design armor layer still remains intact (i.e., suggesting settlement of the cap subgrade), no further action will be required for that particular monitoring event. However, the area will be identified on a map for future inspections as part of the regularly scheduled monitoring.
- If cap inspections verify a loss of 6 or more inches has occurred (relative to previous elevation survey) at three or more contiguous locations (in any direction) is confirmed and if the presence of the design armor stone thickness cannot be verified, a GPS will be used to map areas of concern. , Dow will notify the agencies within one month of the findings. If further work is needed to ensure the ongoing protectiveness of the cap, Dow will develop a timely plan to address these conditions with the Agencies and submit the plan for Agency review and approval. Construction or maintenance response time-frames will be dependent on weather and river conditions. If necessary, repairs will be completed during the same year that the issue was identified, provided that worker safety can be adequately ensured..
- If physical inspections of the reconstructed island overlying the cap verify a loss of 6 or more inches has occurred, the area will be identified on a map for future inspections as part of the regularly scheduled monitoring to determine if the underlying cap becomes exposed.

3 Reporting Schedule

Table 1 summarizes the monitoring schedule. Monitoring activities will be reported to the Agencies within the Annual Progress Report or sooner if issues of concern are identified.

If the threshold in Table 1 is exceeded, the cap inspection described in Section 2.2 will be performed to determine if erosion of the armor cap has occurred and subsequently map the areas of concern.

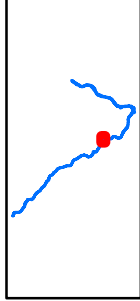
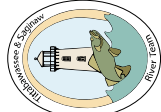
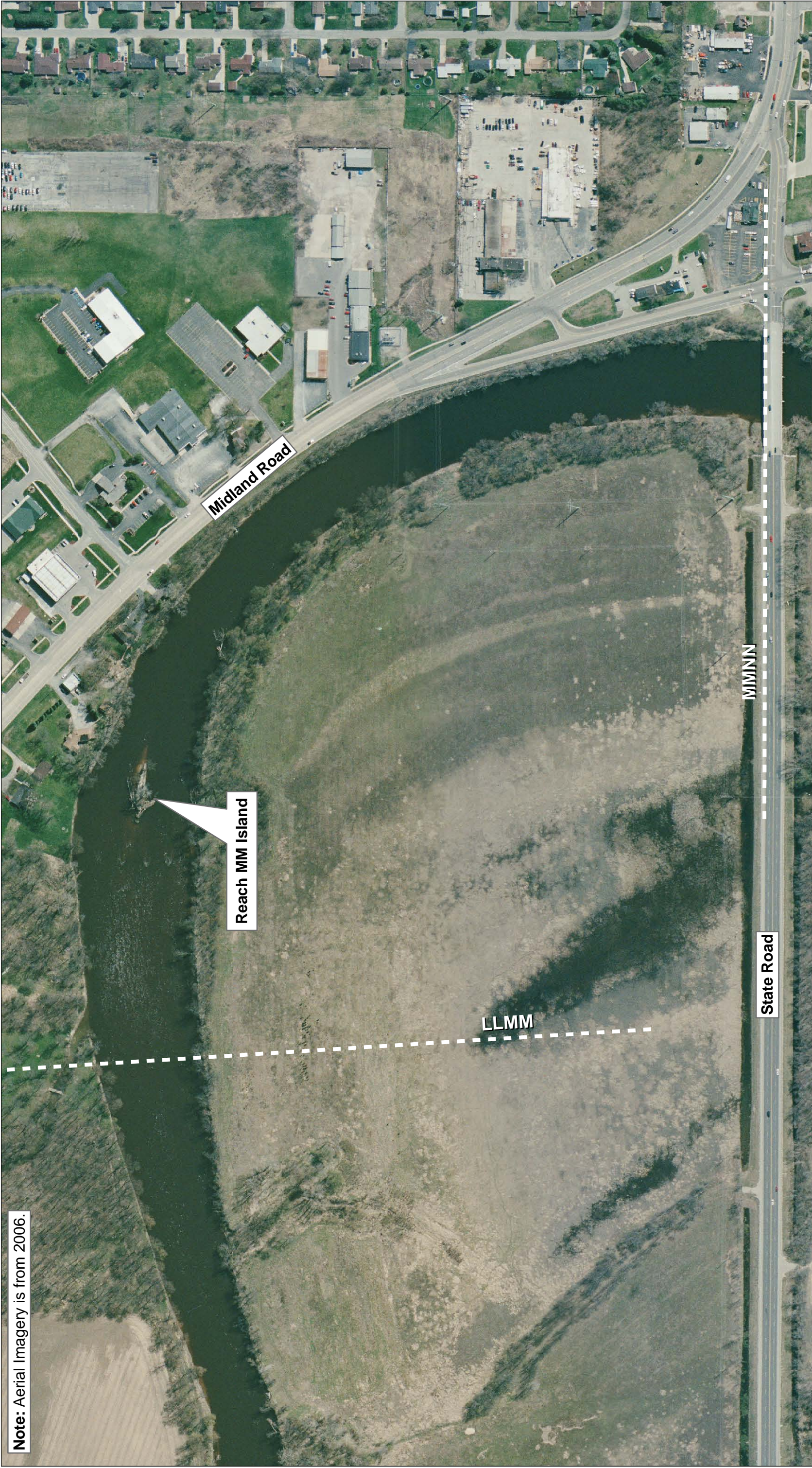
If monitoring and inspections indicate that further work is needed to ensure the ongoing protectiveness of the cap, Dow will notify the Agency within a month and develop a timely plan to address these conditions with the Agencies and submit the plan for Agency review and approval. Construction or maintenance response time-frames will be dependent on weather and river conditions. If necessary, repairs will be completed during the same year that the issue was identified, provided that worker safety can be adequately ensured.

4 References

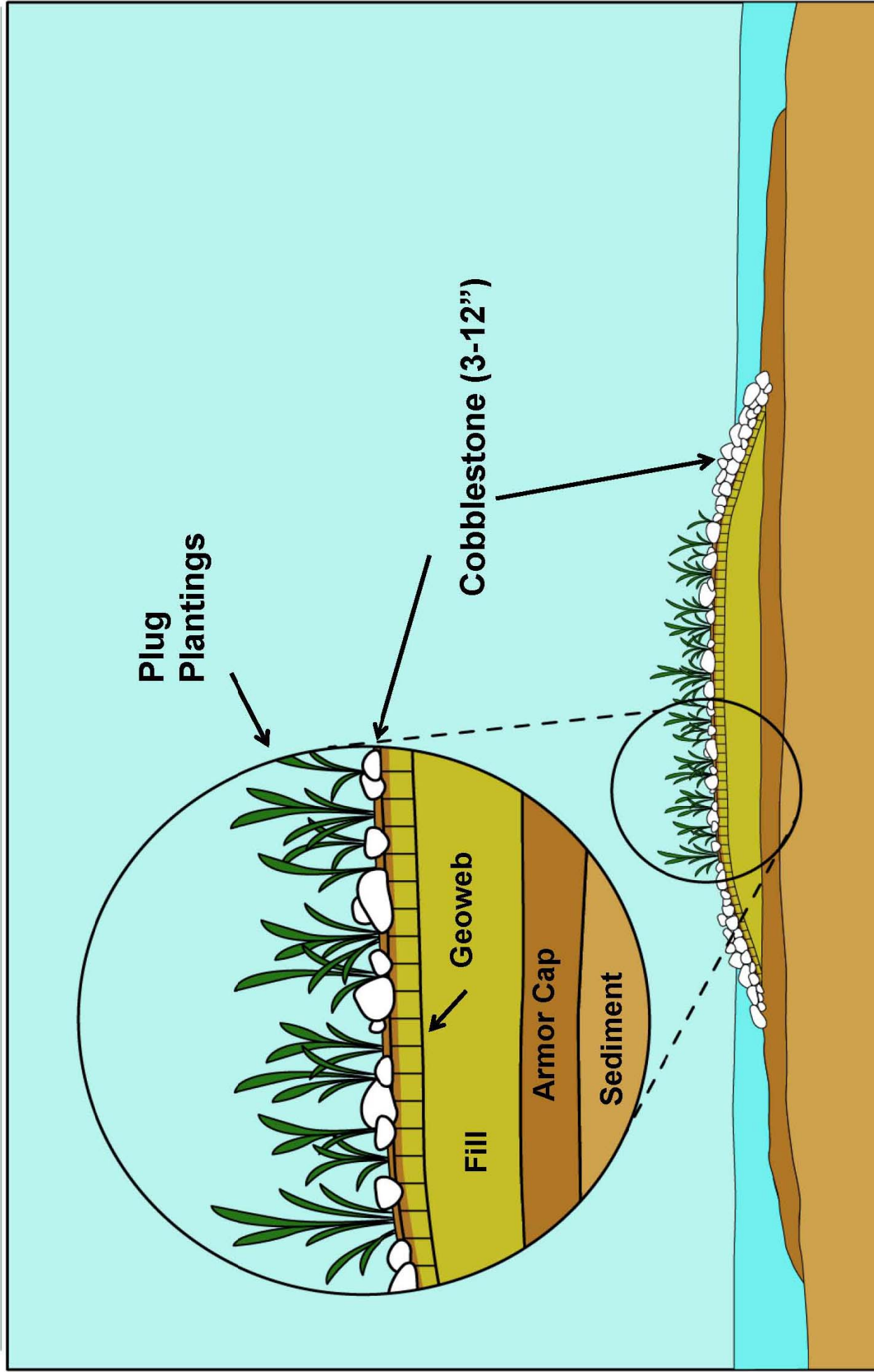
The Dow Chemical Company (Dow), 2011. *Reach MM In-Channel Island Removal Action Report*. The Tittabawassee/Saginaw River & Bay Site. November 30, 2011.

Figures

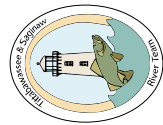
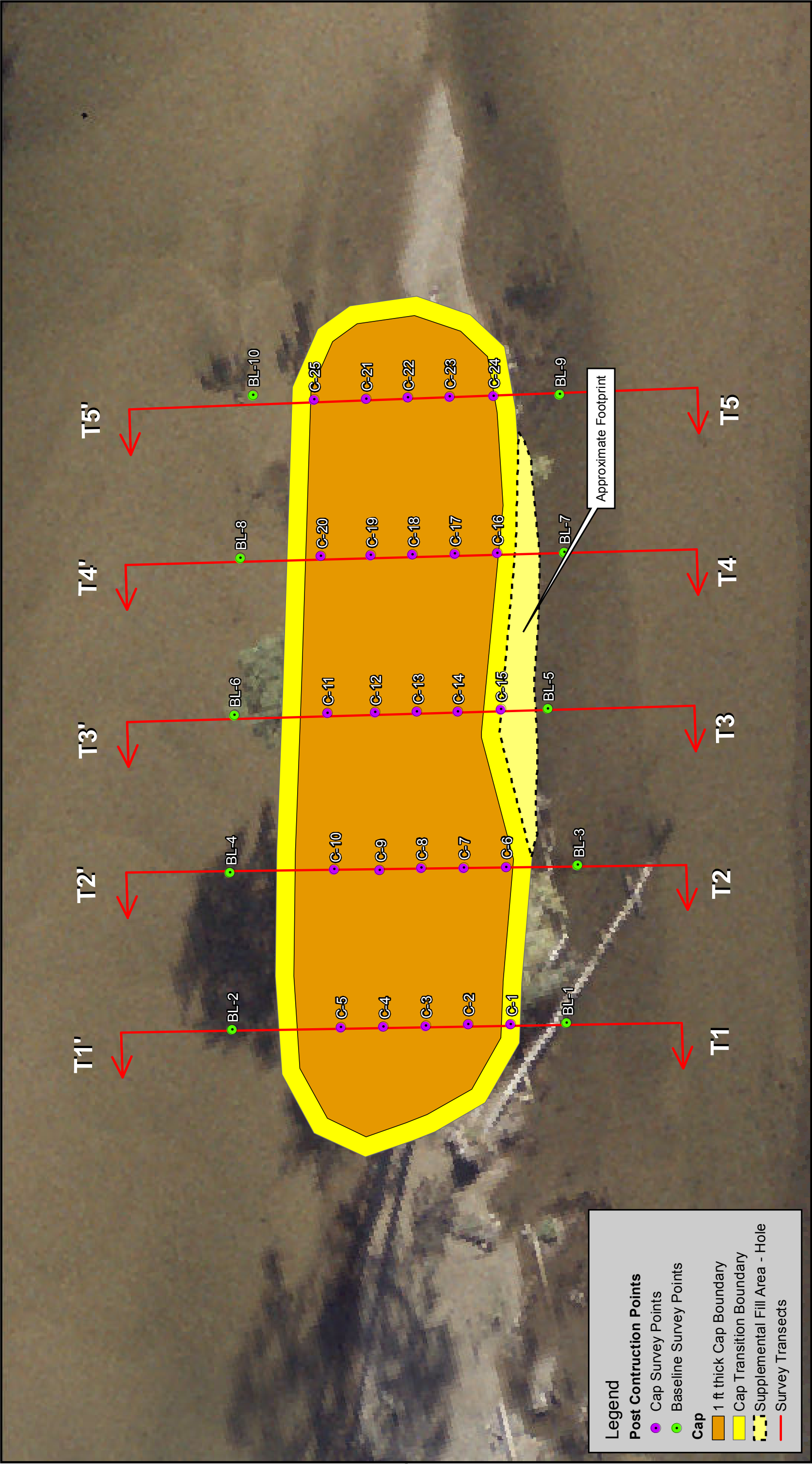
Note: Aerial Imagery is from 2006.



Site Location
Reach MM Island Removal Action Report

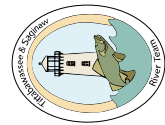
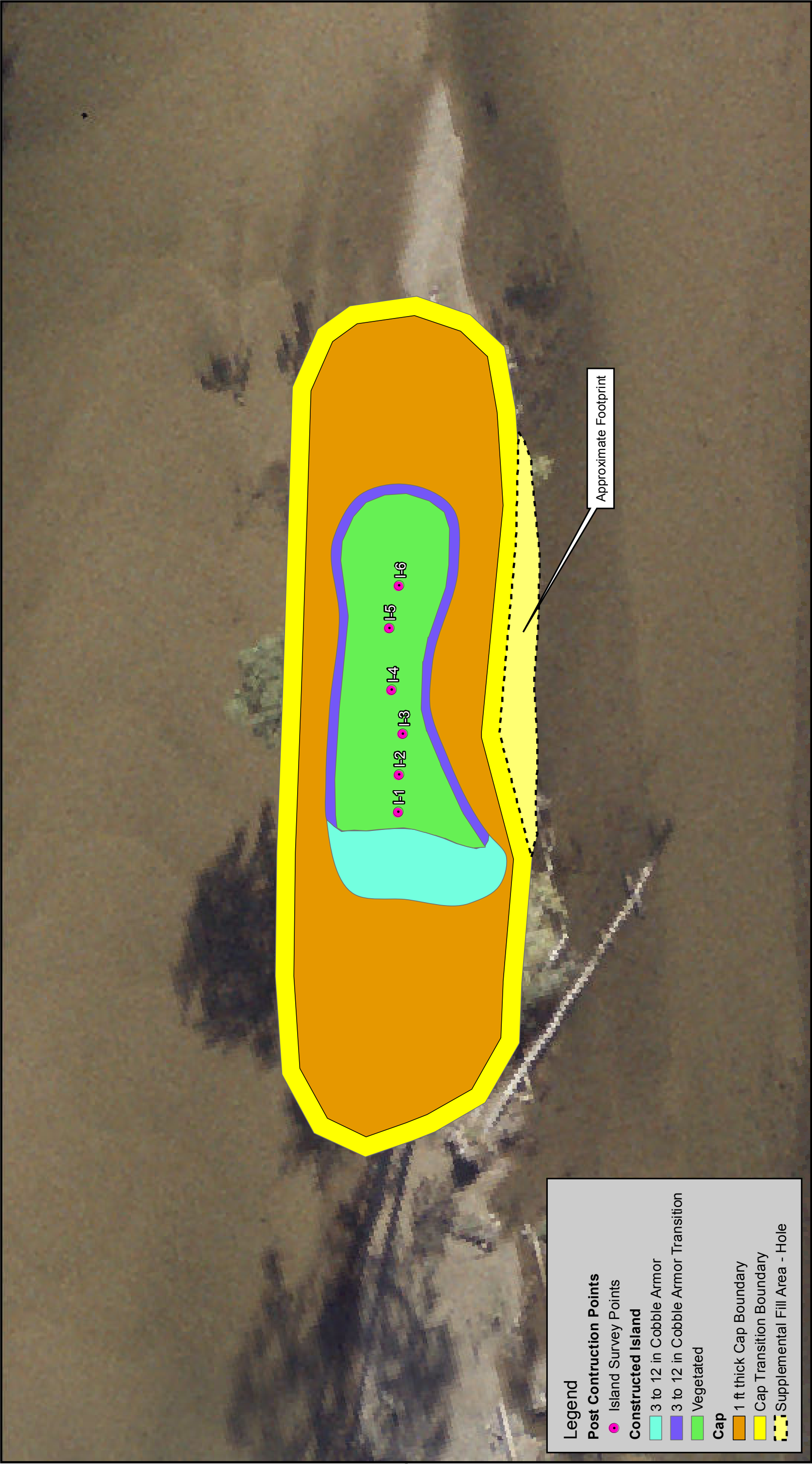


Cap and Island Cross Section
Reach MM Island Removal Action Report



**Post-Construction Armor
Cap Elevation Survey Points**
Reach MM Island Removal Action Report





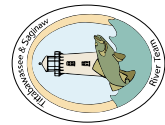
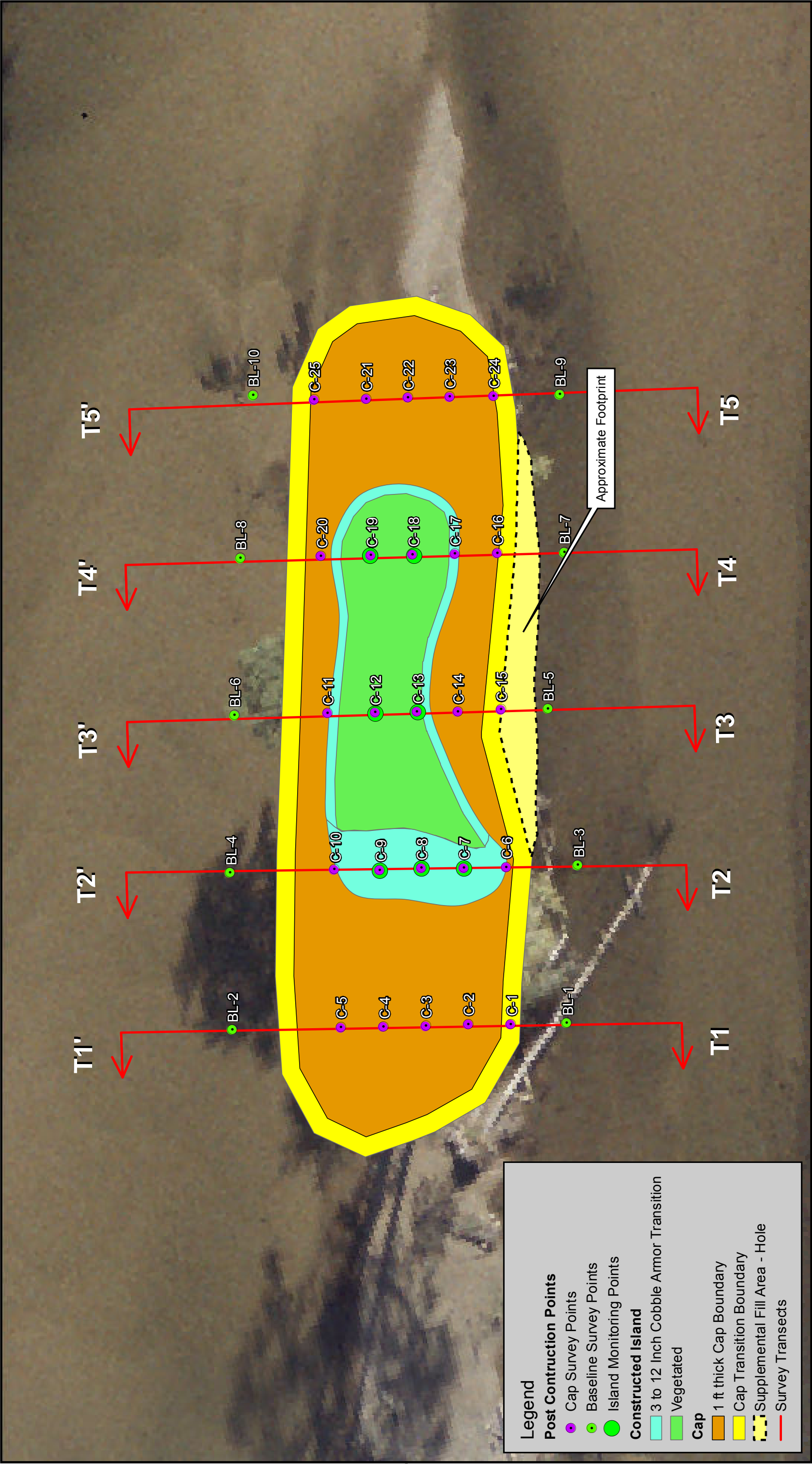


Table 2. Post Construction Elevation Survey

Point ID ²	Sediment Elev (Feet) ¹	Final Cap Elev (Feet)	Final Cap Thickness (Feet)	Comments
C-1	579.13	580.11	0.97	
C-2	579.09	580.12	1.02	
C-3	579.48	580.42	0.94	
C-4	579.15	580.10	0.95	
C-5	578.39	579.70	1.31	
C-6	578.69	579.64	0.95	
C-7* ³	579.22	580.19	0.97	12/5/11 top of island elev = 580.63
C-8*	578.97	580.25	1.28	12/5/11 top of island elev = 580.55
C-9*	579.17	580.08	0.90	12/5/11 top of island elev = 580.58
C-10	578.33	579.15	0.82	
C-11	577.10	578.19	1.09	
C-12*	578.41	579.49	1.08	12/5/11 top of island elev = 580.04
C-13*	578.10	578.99	0.90	12/5/11 top of island elev = 580.33
C-14	574.89	577.12	2.23	Hole in river bottom needed filling
C-15	574.75	575.60	0.85	
C-16		577.03		Hole - too deep to survey sediment elev.
C-17	577.15	577.85	0.70	
C-18*	578.98	579.98	0.99	12/5/11 top of island elev = 580.16
C-19*	579.09	579.65	0.56	12/5/11 top of island elev = 580.83
C-20	577.35	578.70	1.35	
C-21	577.73	578.69	0.96	
C-22	579.03	579.92	0.88	
C-23	579.23	580.06	0.83	
C-24	579.40	579.75	0.35	Along the transition of the cap to sediment
C-25	577.77	578.62	0.85	
Average Cap Thickness			0.99	
BL-1	578.24			Baseline elevations - outside cap footprint
BL-2	576.45			Baseline elevations - outside cap footprint
BL-3	578.19			Baseline elevations - outside cap footprint
BL-4	576.93			Baseline elevations - outside cap footprint
BL-5	578.37			Baseline elevations - outside cap footprint
BL-6	576.99			Baseline elevations - outside cap footprint
BL-7	578.61			Baseline elevations - outside cap footprint
BL-8	576.97			Baseline elevations - outside cap footprint
BL-9	576.90			Baseline elevations - outside cap footprint
BL-10	576.59			Baseline elevations - outside cap footprint
I-1		579.90		Surface of island post installation
I-2		579.83		Surface of island post installation
I-3		579.86		Surface of island post installation
I-4		579.96		Surface of island post installation
I-5		580.20		Surface of island post installation
I-6		581.28		Surface of island post installation

1. Suvey data is represented in North American Vertical Datum (NAVD) 88 in feet

2. C = Cap Survey Point; BL = Baseline Survey Point outside cap footprint; I = Post Construction Island survey point. Surveyed on August 23, 2011.

3. C-7 * = Dual purpose monitoring point used for both armor cap and constructed island monitoring. These points were surveyed on December 5, 2011.

Appendix E: Cost Estimate

Reach MM Island Costs

Item #	Item Description	Contractor	Item Costs
1	Work Plan Development & Investigation	Anchor QEA	\$29,000
2	Analytical Work	Dow Contractor	\$14,125
3	Project Oversight, EH&S	Kelly Services (Dow)	\$39,195
4	Mobilization, Site Prep, Access, Demobilization - Materials and Labor	Fisher Contracting	\$218,161
5	Island Removal & Disposal	Fisher Contracting	\$47,740
6	Cap Placement & Island Reconstruction - Materials and Labor	Fisher & Servinski	\$69,077
7	Site Restoration - Materials and Labor	Fisher & Servinski	\$99,270
Total Construction Costs			\$516,569

Appendix F: Photographic Log of Project

PHOTOGRAPHIC LOG

Client Name: Dow Chemical		Site Location: MM Island	Project No. 476
Photo No. 1	Date: 08/12/2011		
Direction Photo Taken: South			
Description: Pre-construction site access through yard adjacent to home.			

Photo No. 2	Date: 08/12/2011	
Direction Photo Taken: Southwest		
Description: Pre-construction site access through yard		

PHOTOGRAPHIC LOG



Client Name: Dow Chemical		Site Location: MM Island	Project No. 476
Photo No. 3	Date: 08/15/2011		
Direction Photo Taken: Southwest			
Description: Installation of Soil Erosion & sedimentation controls (silt fence)			

Photo No. 4	Date: 08/15/2011	
Direction Photo Taken: Southwest		
Description: Installation of temporary woven geotextile to support asphalt millings used for temporary site access.		

PHOTOGRAPHIC LOG


Client Name: Dow Chemical		Site Location: MM Island	Project No. 476
Photo No. 5	Date: 08/15/2011		
Direction Photo Taken: Southwest			
Description: Temporary access road toward river and temporary laydown area.			

Photo No. 6	Date: 08/16/11	
Direction Photo Taken: Southwest		
Description: Installation of temporary access road and temporary laydown area.		

PHOTOGRAPHIC LOG



Client Name: Dow Chemical		Site Location: MM Island	Project No. 476
Photo No. 7	Date:	 <p>08.16.2011</p>	
Direction Photo Taken: Northeast			
Description: Operation of dust suppression system for temporary access road.			

Photo No. 8	Date: 08/16/2011	
Direction Photo Taken: South		
Description: Pre-Removal of MM Island		

PHOTOGRAPHIC LOG

Client Name: Dow Chemical		Site Location: MM Island	Project No. 476
Photo No. 9	Date: 08/18/2011		
Direction Photo Taken: Southwest			
Description: Excavator entering water for first time. Preparing to set first bridge abutment			

Photo No. 10	Date: 08/18/2011	
Direction Photo Taken: Southwest		
Description: Excavator placing crane mats on river bottom to support crane transport and minimize river bottom disturbance.		

PHOTOGRAPHIC LOG

Photo No.
11

Date:
08/18/2011

Direction Photo Taken:
Southwest

Description:

Crane placing first
bridge abutment



Photo No.
12

Date:
08/18/2011

Direction Photo Taken:
West

Description:

Placement of second
half of first bridge
section



PHOTOGRAPHIC LOG

Client Name: Dow Chemical		Site Location: MM Island	Project No. 476
Photo No. 13	Date: 08/18/2011		
Direction Photo Taken: Southeast			
Description: Completion of temporary bridge installation			

Photo No. 14	Date: 08/18/2011	
Direction Photo Taken: East		
Description: Downstream view from bridge showing buoy placement for directing boat traffic		

PHOTOGRAPHIC LOG


Client Name: Dow Chemical		Site Location: MM Island	Project No. 476
Photo No. 15	Date: 08/19/2011		
Direction Photo Taken: Northwest			
Description: Looking upstream from boat downstream of MM Island and temporary bridge showing temporary signage and buoy placement for directing boat traffic			

Photo No. 16	Date: 08/19/2011	
Direction Photo Taken: South		
Description: Excavator positioning crane mats between in-channel end of temporary bridge and MM Island prior to removal.		

PHOTOGRAPHIC LOG



Client Name: Dow Chemical		Site Location: MM Island	Project No. 476
Photo No. 17	Date: 08/19/2011	 <p>08.19.2011</p>	
Direction Photo Taken: Southeast			
Description: Excavator removing sediment/soil and woody debris for MM Island			

Photo No. 18	Date: 08/19/2011	 <p>08.19.2011</p>
Direction Photo Taken: South		
Description: Excavator placing sediment/soil and woody debris into lined transport truck. Material to be sent to Peoples Landfill for disposal.		

PHOTOGRAPHIC LOG



Client Name: Dow Chemical		Site Location: MM Island	Project No. 476
Photo No. 19	Date: 08/19/2011		
Direction Photo Taken: Southeast			
Description: Downstream limits of MM Island prior to removal and showing silt curtain in place			

Photo No. 20	Date: 08/20/2011	
Direction Photo Taken: West		
Description: Excavator placing MM Island sediments/soil & woody debris into lined transport truck.		

PHOTOGRAPHIC LOG


Client Name: Dow Chemical		Site Location: MM Island	Project No. 476
Photo No. 21	Date: 08/20/2011		
Direction Photo Taken: Southeast			
Description: Excavator removing sediment/soils & woody debris from upstream limits of MM Island.			

Photo No. 22	Date: 08/21/2011	
Direction Photo Taken: East		
Description: Excavator placement of armor stone and survey verification on downstream end of cap area		

PHOTOGRAPHIC LOG

Photo No.
23

Date:
08/21/2011

Direction Photo Taken:

Southeast

Description:

Downstream portion of capped area with armor stone



Photo No.
24

Date:
08/22/2011

Direction Photo Taken:

Northwest

Description:

Placement of silty-sand material to reconstruct island. Nylon tendons on reels are for Geoweb installation.



PHOTOGRAPHIC LOG


Client Name: Dow Chemical		Site Location: MM Island	Project No. 476
Photo No. 25	Date: 08/22/2011	 <p>08.22.2011</p>	
Direction Photo Taken: West - upstream			
Description: Installation of GW-30V-6-08-29 Geoweb overtop of placed silty-sand material used to form the reconstructed island.			

Photo No. 26	Date: 08/22/2011	 <p>08.22.2011</p>
Direction Photo Taken: Southeast		
Description: 3 to 12 inch cobble stone being placed by excavator around perimeter to secure Geoweb.		

PHOTOGRAPHIC LOG

Client Name: Dow Chemical		Site Location: MM Island	Project No. 476
Photo No. 27	Date: 08/22/2011		
Direction Photo Taken: East - Upstream			
Description: Mechanical and manual placement of silty-sand material within cells of Geoweb.			

Photo No. 28	Date: 08/22/2011	
Direction Photo Taken: East - Upstream		
Description: Mechanical and manual placement of 3- to 12-inch cobble stone material on top of recently placed silty-sand material.		

PHOTOGRAPHIC LOG


Client Name: Dow Chemical		Site Location: MM Island	Project No. 476
Photo No. 29	Date: 08/22/2011	 <p>08.22.2011</p>	
Direction Photo Taken: Southwest			
Description: Downstream view of reconstructed island			

Photo No. 30	Date: 08/22/2011	 <p>08.22.2011</p>
Direction Photo Taken: South		
Description: Upstream installation of reconstructed island.		

PHOTOGRAPHIC LOG

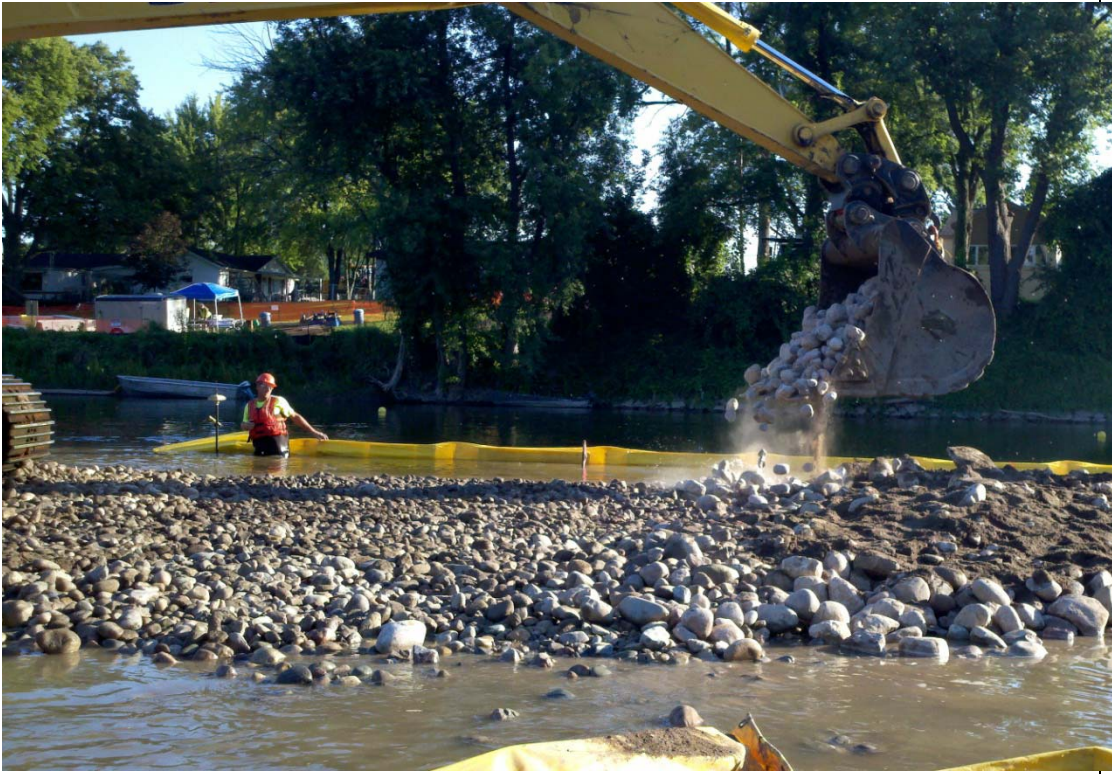
Client Name: Dow Chemical		Site Location: MM Island	Project No. 476
Photo No. 31	Date: 08/23/2011		
Direction Photo Taken: North			
Description: Placement of 3- to 12-inch cobble armor on upstream portion of reconstructed island.			

Photo No. 32	Date: 08/23/2011	
Direction Photo Taken: South		
Description: Aerial photo of downstream portion of cap area and reconstructed island.		

08.23.2011

PHOTOGRAPHIC LOG

Client Name: Dow Chemical		Site Location: MM Island	Project No. 476
Photo No. 33	Date: 08/24/2011		
Direction Photo Taken: East			
Description: Installation of purchased and translocated plants.			

Photo No. 34	Date: 08/24/2011	
Direction Photo Taken: East		
Description: Manual irrigation of recently installed plants.		

PHOTOGRAPHIC LOG


Client Name: Dow Chemical		Site Location: MM Island	Project No. 476
Photo No. 35	Date: 08/24/2011	 <p>08.24.2011</p>	
Direction Photo Taken: Southwest			
Description: Reconstructed island complete.			

Photo No. 36	Date: 08/24/2011	 <p>08.24.2011</p>
Direction Photo Taken: South		
Description: Demobilization of temporary bridge system.		

PHOTOGRAPHIC LOG


Client Name: Dow Chemical		Site Location: MM Island	Project No. 476
Photo No. 37	Date: 08/29/2011		
Direction Photo Taken: Southwest			
Description: Removal of floodplain soils to prepare for sod installation.			

Photo No. 38	Date: 08/29/2011	
Direction Photo Taken: North		
Description: Temporary irrigation system.		

PHOTOGRAPHIC LOG


Client Name: Dow Chemical		Site Location: MM Island	Project No. 476
Photo No. 39	Date: 08/31/2011		
Direction Photo Taken: Southwest			
Description: Installation of sod within floodplain.			

Photo No. 40	Date: 08/31/2011	
Direction Photo Taken: Southwest		
Description: Installation of temporary irrigation heads to irrigate sod.		